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BULLETIN

OF THE

UNITED STATES

GEOLOGICAL SURVEY

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WASHINGTON
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1900

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

CONTRIBUTIONS

TO

CHEMISTRY AND MINERALOGY

FROM THE

LABORATORY OF THE UNITED STATES GEOLOGICAL SURVEY

FRANK W. CLARKE

CHIEF CHEMIST

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

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ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY.
Washington, D. C., November 4, 1899.

SIR: I submit herewith a manuscript entitled Contributions to Chemistry and Mineralogy from the Laboratory of the United States Geological Survey. I have the honor to request that it be published as a bulletin of the Survey.

Very respectfully,

F. W. CLARKE,
Chief Chemist.

HON. CHARLES D. WALCOTT,
Director United States Geological Survey.

PREFATORY NOTE.

In the following pages there have been brought together a variety of chemical and mineralogical researches, which were carried out in the laboratory of the United States Geological Survey between July 1, 1893, and July 1, 1899. In one sense the bulletin is a continuation of the series represented by Bulletins Nos. 9, 42, 55, 60, 64, 78, 90, and 113; only, unlike them, it reports no miscellaneous analyses. The latter represent by far the larger part of the work done in the laboratory; but most of them are published in other form, in connection with the geological investigations to which they relate. Their repetition here is unnecessary.

F. W. C.

CONTRIBUTIONS TO CHEMISTRY AND MINERALOGY.

EXPERIMENTS RELATIVE TO THE CONSTITUTION OF PECTOLITE, PYROPHYLLITE, CALAMINE, AND ANALCITE.

By F. W. CLARKE and GEORGE STEIGER.

In a series of investigations by Clarke and Schneider, which were carried out in the laboratory of the United States Geological Survey between 1889 and 1892,[1] a number of reactions were examined which shed some light upon the constitution of several natural silicates. The work then begun was unfortunately interrupted for several years; but it is now resumed, with the hope that it may be pushed considerably further.

Two of the reactions studied by Clarke and Schneider were of peculiar interest. First, in the case of talc, it was found that one-fourth of the silica could be liberated by ignition; and that the fraction thus set free was measurable by solution in aqueous sodium carbonate. This reaction suggests that other acid metasilicates may behave in a similar way, and that we perhaps have a means of discrimination between such salts and other compounds which simulate them. In other words, an acid metasilicate may be experimentally distinguished from a pseudometasilicate by the way in which it splits up when ignited. Evidence bearing upon this supposition will be found in the present paper.

The second of the reactions just referred to is that between dry ammonium chloride, at its temperature of dissociation, and various silicates.[2] This involves, in part at least, the action of dry gaseous hydrochloric acid upon the compounds which are studied; and different minerals are very differently attacked. Some are almost completely decomposed, others are affected but slightly; and here again there seems to be a method of diagnosis which deserves further attention. Both reactions suggest the main purpose of the investigation; which is, the fractional analysis of silicates by means of various reagents, in

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[1] Bull. U. S. Geol. Survey No. 78, p. 11; Bull. No. 90, p. 11; Bull. No. 113, p. 27.

[2] Bull. U. S. Geol. Survey No. 113, p. 34.

order to gain evidence bearing upon their chemical structure. The evidence, at least, is of value, whether the interpretation of it be right or wrong. Each fact helps to the ultimate solution of the central problem, the problem of constitution.

PECTOLITE.

The pectolite which was chosen for examination was the well-known radiated variety from Bergen Hill, New Jersey. The mineral was in long, white needles, and apparently quite pure; but the analysis shows that it contained some carbonate as an impurity. Enough of the material was ground up to furnish a uniform sample for the entire series of experiments, and the work properly began with a complete analysis. The results obtained are as follows:

Analysis.

SiO_2	53.34
Al_2O_3	.33
CaO	33.23
MnO	.45
Na_2O	9.11
Total H_2O	2.97
CO_2	.67
	100.10

Fractional water.

At 105°	0.27
At 180°	.16
At 300°	.22
At redness	2.32
	2.97

All of the water was given off at a barely visible red heat; and the figures show that practically all of it is constitutional, a fact which perhaps hardly needed reverification. The analysis gives the accepted formula for pectolite,

$$HNaCa_2Si_3O_9.$$

Does this represent, as is commonly assumed, a true metasilicate? If it does, we should expect that ignition would split off silica proportional to the acid hydrogen, or one-sixth of the total amount. To answer this question several portions of the pectolite were sharply ignited, to complete dehydration, and then boiled each for fifteen minutes with a solution of sodium carbonate containing 250 grams to the liter. In the extract so obtained the silica was determined; and three experiments gave the following percentages:

	8.96
	8.67
	8.42
Mean,	8.68

One-sixth of the total silica is 8.89 per cent; and the experiments, therefore, justify the original expectation. The belief that pectolite is a metasilicate is effectively confirmed.

Upon the unignited pectolite the sodium carbonate solution has a slow decomposing action, both silica and bases being withdrawn. In two experiments fifteen minutes of boiling extracted 2.07 and 2.55 per cent of silica, and by a treatment lasting four days 4.80 per cent was taken out. With water alone similar results were obtained; the action being so rapid, although relatively slight, that pectolite, moistened, gives an immediate and deep coloration with phenol phthalein. By boiling the powdered pectolite with distilled water alone 1.65 per cent of silica was brought into solution, and the ignited mineral, similarly treated for fifteen minutes, gave 1.78 per cent. The extraction in these cases is really an extraction of alkaline silicate, as the two following experiments prove. In A the unignited pectolite was boiled for fourteen hours with distilled water; and in B the mineral after ignition was subjected to like treatment for four hours. The dissolved matter in each case was determined, with the subjoined results:

	A.	B.
SiO_2	2.98	3.03
CaO	.30	.10
Na_2O	.81	1.50
	4.09	4.63

In A, no simple ratio appears; but in B the extracted silicate approximates very nearly to the salt $Na_2Si_2O_5$. In each instance the ratios vary widely from those of the original mineral, showing that actual decomposition and not a solution of the pectolite as such has occurred.

In the experiments upon pectolite the heating with dry ammonium chloride was omitted, for the data are already given in the original paper by Schneider and Clarke. In their experiments the mineral was thrice heated with ten times its weight of the reagent to above 350°, and then leached out with water. In the solution 20.50 per cent of lime and 6.95 of soda were found, with part of the manganese; showing that a very considerable decomposition had taken place. Possibly, by repeated treatments with ammonium chloride a complete decomposition might be effected, but this question is one upon which it seemed unnecessary to spend further time.

PYROPHYLLITE.

The empirical formula for pyrophyllite, $AlHSi_2O_6$ is apparently that of an acid metasilicate, and the mineral is therefore peculiarly available for fractional analysis. The compact variety from Deep River, North Carolina, was taken for examination, and a uniform sample was prepared. Analysis gave the following results:

SiO_2	64.73
TiO_2	.73
Al_2O_3	29.16
Fe_2O_3	.49
MgO	trace
Ignition	5.35
	100.46

If, now, pyrophyllite is an acid metasilicate it should break up on ignition in accordance with the equation

$$2AlHSi_2O_6 = Al_2Si_3O_9 + SiO_2 + H_2O.$$

That is, one-fourth of the silica, or 16.18 per cent, should be liberated. The mineral itself is very slightly attacked by boiling with the sodium carbonate solution, and in an experiment of this kind only 0.72 per cent of silica was dissolved. Upon ignition under varying circumstances the following data were obtained:

Ignited ten minutes over a Bunsen burner, and then extracted with sodium carbonate solution, 1.51 per cent of SiO_2 dissolved.

Ignited fifteen minutes over a Bunsen burner, 1.89 per cent became soluble.

Ignited ten minutes over a Bunsen burner and then fifteen minutes over the blast, 2.84 per cent of silica was liberated.

These results are of a different order from those given by pectolite and talc, and raise the question whether pyrophyllite, despite its ratios, is a metasilicate at all. So far as the evidence goes, it may with propriety be regarded as a basic salt of the acid $H_2Si_2O_5$, and its formula then becomes

$$Si_2O_5 = Al - OH.$$

This formula is at least as probable as the metasilicate expression, which latter rests upon assumption alone. Still other formulæ, but of greater complexity, are possible; but until we know more of the genesis and chemical relationships of pyrophyllite, speculation concerning them would be unprofitable.

By heating with dry ammonium chloride, pyrophyllite is very slightly attacked. In two experiments it lost in weight 6.17 and 6.30 per cent, respectively. The excess of loss over water is due, as we have proved, to the volatilization of a little ferric and aluminic chloride. The residue of the mineral after this treatment contained no chlorine, so that no chlorhydrin-like body had been formed. The formation of such a compound, the replacement of hydroxyl by chlorine, would, if it could be effected, be a valuable datum toward determining the actual constitution of the species.

CALAMINE.

The simplest constitutional formula for calamine, the one which is generally accepted, represents it as a basic metasilicate, $SiO_3=(ZnOH)_2$. In this the hydrogen is all combined in one way, and so, too, is the zinc. In all other possible formulæ, simple or complex, the hydrogen as well as the zinc must be represented as present in at least two modes of combination; a condition of which, if it exists, some evidence should be attainable. Our experiments upon calamine have had this point in view; and we have sought to ascertain whether water or zinc could be split off in separately recognizable fractions. Our results, in the main, have been negative, and tend toward the support of the usual formula; but the data are not conclusive, although they seem to be worthy of record.

The beautiful white calamine from Franklin Furnace, New Jersey, was selected for study, and gave the subjoined composition:

Analysis.

SiO_2	24.15
Al_2O_3,Fe_2O_3	.19
ZnO	67.55
CaO	.12
H_2O	7.95
	99.96

Fractional water.

At 100°	.27
At 180°	.22
At 250°	.75
At 300°	.88
Incipient red heat	4.46
Full red heat	1.37
	7.95

Here no clear and definite fractionation of the water is recognizable, at least of such a character as to suggest any other than the ordinary formula for calamine.

Upon boiling powdered calamine with water practically nothing went into solution, but by boiling with the solution of sodium carbonate 0.25 per cent of silica was dissolved. After ignition at a red heat, only 0.14 per cent of silica became soluble in sodium carbonate, and after blasting, only 0.24. In these experiments a very little zinc was dissolved also; but there was no evidence that any breaking up of the mineral into distinguishable fractions had occurred. In a hot 10 per cent solution of caustic soda both the fresh and the ignited calamine dissolve almost completely; but boiling with aqueous ammonia seems to leave the mineral practically unattacked. All experiments aiming to extract a definite fraction of zinc while leaving a similar fraction behind resulted negatively.

By heating with dry ammonium chloride, calamine is vigorously attacked, and gains in weight by absorption of chlorine. In two experiments the mineral was intimately mixed with three times its weight of powdered salammoniac and heated in an air bath for several hours to a temperature somewhat over 400°. A large part of the residue was soluble in water, and the percentage of this portion, together with the percentage increase in weight, is given below.

	I.	II.
Gain in weight	27.60	25.78
Soluble in water	53.23	67.13

A conversion of calamine into the chlorhydrin, $SiO_3 (ZnCl)_2$ would involve a gain in weight of 15.34 per cent. Complete conversion into $2ZnCl_2 + SiO_2$ implies an increase of 38.14 per cent. The figures given lie between these two; and are indefinite also for the reason that there was volatilization of zinc chloride.

In two more experiments the calamine, mingled with three times and four times its weight of ammonium chloride, respectively, was heated for an hour and a half to bright redness in a combustion tube. The zinc chloride which was formed, volatilized, and was collected by suitable means for determination. It corresponded to 59.6 and 59.0 per cent of the original mineral, calculated as zinc oxide; which indicates a nearly complete decomposition of the calamine into $2ZnCl_2 + SiO_2$. The residue was mainly silica, with a small part of the zinc, about half of the silica being soluble in sodium carbonate solution. Here again no definite fractionation of the mineral could be observed.

Finally the action of dry hydrogen sulphide upon calamine was investigated. The mineral was heated to redness in a current of the gas, and gained perceptibly in weight. The percentage data, reckoned on the original calamine, were as follows, in two experiments:

	I.	II.
Gain in weight	6.00	6.43
SiO_2 soluble in Na_2CO_3	16.45	20.95
Sulphur in residue	....	24.12

Complete conversion of calamine into $2ZnS + SiO_2$ implies a gain in weight of 5.80 per cent; and it is therefore evident from the figures of the second experiment that the limit of change was approached very nearly. The 24.12 of sulphur taken up is quite close to the 26.53 per cent which is required by theory. About eight-ninths of the calamine had undergone complete transformation. Again, no definite fractionation was detected.

The hydrogen sulphide reaction was examined still further with reference to the temperature at which it becomes effective. Even in the cold calamine is slightly attacked by the gas, but its action is unimportant until the temperature of 400° is approximated. Then it becomes vigorous and the reaction goes on rapidly. A few experiments with willemite showed that it also was attacked by hydrogen sulphide, but less vigorously than calamine.

ANALCITE.

Analcite, from many points of view, is a species of peculiar interest, and of late years it has received a great deal of attention. Its formula may be written in various ways, especially as regards the interpretation of its one molecule of water; but evidence too often has yielded before preconceived opinion. Additional evidence is now available, partly from the experiments of Friedel and partly from the data obtained during the present investigation.

The analcite examined by us was in well-developed crystals from Wassons Bluff in Nova Scotia. A uniform sample was prepared as usual, and the analysis given below is contrasted with the theoretical composition required by the accepted empirical formula $NaAlSi_2O_6 H_2O$.

Analysis.

	Found.	Calculated.
SiO_2	57.06	54.55
Al_2O_3	21.48	23.18
Fe_2O_3	.13	....
CaO	.16	....
Na_2O	12.20	14.09
H_2O at 100°	.58	....
H_2O over 100°	8.38	8.18
	99.99	100.00

Fractional water.

At 100°	0.58
At 180°	1.16
At 260°	3.64
At 300°	1.57
Low redness	1.90
Full redness	0.11
Blast	none
	8.96

The fractional water determinations were made by heating in an air bath to constant weight at each temperature up to 300° and finally over the direct flame. The first fraction, at 100°, is evidently hygroscopic or extraneous water, which can be disregarded. The remainder of the water, 8.38 per cent, belongs to the species. The significance of the analytical figures will be considered later.

Upon boiling the powdered analcite with sodium carbonate solution, 250 grams to the liter as in all the preceding experiments, 0.73 per cent of silica was extracted. After ignition the mineral in two determinations yielded 1.46 and 1.38 per cent respectively. The splitting off of silica is therefore very slight; and one of the formulæ proposed by Doelter,[1] $Na_2Al_2Si_2O_8 + 2H_2SiO_3$, may be set aside as improbable. Metasilicic acid or an acid metasilicate can hardly be present in analcite, although the possibility of a neutral metasilicate, as indicated by the empirical formula, is not excluded. By Doelter's formula one-half of the silica ought to be removable.

Upon heating analcite with dry ammonium chloride results of a remarkable character were obtained. Sodium chloride was formed which could be leached out by water and measured, while ammonia free from chlorine was retained by the residue to a notable and surprisingly stable degree. The experiments in detail were as follows:

A. Analcite, mixed with four times its weight of ammonium chloride was heated for four hours to 350°. There was a gain in weight of 2.18 per cent, and 6.10 per cent of soda, or one-half of the total amount, was converted into NaCl, which was leached out by water, examined as to its purity, and weighed. In the residue 1.20 per cent of silica was extractable by sodium carbonate, showing that no more splitting off had occurred than was previously observed. The gain in weight, as will be seen from subsequent experiments, is due to the fact that all of the NH_4Cl had not been driven off; or else that more water was retained.

B. Analcite was ground up with four times its weight of NH_4Cl, heated for several hours, reground with another fourfold portion of chloride, and heated to 350° for twenty-one hours. Gain in weight, 0.08 per cent; 5.57 per cent of soda was extracted as chloride.

C. Analcite heated to 350° for eight hours, with four times its weight of NH_4Cl. Loss of weight, 0.10 per cent.

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[1] Neues Jahrb. für Min., 1890, Vol. I, p. 133.

D. Six grams of mineral and 28 of chloride, mixed by thorough grinding, were heated to 350° for fourteen hours; then were reground with 28 grams of fresh NH_4Cl and heated for thirty-five hours. Loss of weight, 0.13 per cent; 5.07 per cent of soda was extracted as chloride, plus 0.14 of ammonium chloride unexpelled; 2.03 per cent of silica was rendered soluble in sodium carbonate.

So far, three facts are noticeable. First, the weight of the mineral after treatment is almost exactly the same as before; showing that gains and losses have balanced each other. Second, little silica has been split off. Third, approximately, but not rigorously, one-half of the soda had been converted into NaCl. In A, it was exactly half; in the other experiments, a little less than half. Furthermore, in the sodium chloride dissolved out there is only a very little ammonium chloride, amounting at most to 0.14 per cent, calculated upon the weight of the original mineral.

In the residue of the analcite after extraction of sodium chloride, abundant ammonia can be detected, with either no chlorine or at most a doubtful trace. If, however, the unleached mineral, still retaining its sodium chloride, be heated strongly, say from 400° up to redness, NH_4Cl is regenerated and given off. Its absence, as such, both from the leach and the residue was repeatedly proved. The ammonia and water retained by the analcite after heating to 350° with ammonium chloride were several times determined; and the following percentages, still reckoned on the original mineral, were found:

	NH_3.	H_2O.
In B	2.03	2.25
In C	2.19	2.00
In D	2.36	1.89
In D	2.35	....
In D	2.06	....
Mean	2.20	2.04

Correcting the ammonia for the 0.14 of NH_4Cl found in D, the mean value becomes 2.15. This permanent ammonia is not given off upon warming the material with caustic soda solution, and is therefore not present as a salt. The determinations of it were made by three distinct methods, and there is no possible doubt as to its presence and character.

The composition of the analcite after the treatment with ammonium chloride may now be considered, with the subjoined combination of the data. The NaCl in A, 11.50 per cent, was in material which had gained 2.18 per cent, and is subject to a correction which reduces the figure to 11.26. In B, C, and D the corresponding correction is so small that it may be neglected. The last column gives the composition of the leached residue, recalculated to 100 per cent, after deduction of NaCl and the soluble silica. The letters refer back to the several experiments, and the little iron is included with the alumina.

	A.	B.	C.	D.	Average.	Residue.
Sol. SiO_2	1.20			2.03	1.61	
Insol. SiO_2				54.96	54.96	62.59
Al_2O_3				21.37	21.37	24.34
CaO				.16	.16	.18
NaCl	11.26	10.50		9.57	10.44	
Na_2O				7.12	7.12	8.11
NH_3		2.03	2.19	2.21	2.15	2.46
H_2O		2.25	2.00	1.89	2.04	2.32
				99.31	99.85	100.00

The analcite residue, like the original mineral, is completely decomposable by aqueous hydrochloric acid. It may be a mixture, but it seems more probable that it is a definite compound, for it approximates in composition to the formula

$$H_2Na_2Al_4Si_8O_{24} \,.\, NH_3.$$

This represents a quadrupled analcite formula, in which half of the sodium is replaced by hydrogen, and with NH_3 in place of $4H_2O$ The analytical comparison is as follows:

	Found.	Calculated.
SiO_2	62.59	61.46
Al_2O_3	24.34	26.12
CaO	.18	
Na_2O	8.11	7.94
H_2O	2.32	2.30
NH_3	2.46	2.18
	100.00	100.00

The agreement is not close, but it is close enough to be suggestive and to indicate the character of the reaction which has taken place. It needs, however, verification by additional experiments upon other preparations, and upon analcite from other sources. In this connection it may be well to reiterate that the substance was prepared by very long heating at 350°, and is therefore stable at that temperature.

An interesting feature of these experiments is their harmony with the researches of G. Friedel,[1] who has shown that the water of zeolites may be replaced by ammonia and other substances, without change of the crystalline structure. In the case of analcite, ammonia was taken up to the extent of 2.04 per cent, or almost exactly the amount found

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[1] Bull. Soc. Min., Vol. XIX, 1896, p. 94.

in our analcite residue. The great difference between Friedel's method of experimentation and ours renders the agreement all the more striking and sustains our belief that the mineral and the residue are compounds of the same general order. We hope to continue our experiments and to extend our investigations to other zeolites.

If, now, analcite and its derivative, our analcite residue, are analogous compounds, the relation between them is expressed by these formulæ:

Analcite.......................................$Na_4Al_4Si_8O_{24} . 4H_2O$.
Analcite residue..............................$H_2Na_2Al_4Si_8O_{24} . NH_3$.

That is, the minimum molecular weight assignable to analcite is represented by four times its empirical formula. Other interpretations of the evidence are possible, but this appears to be the simplest. The water of analcite, as Friedel has shown, must be regarded as water only, not as hydroxyl, for it can be expelled by heat without destruction of the crystalline nucleus, the anhydrous salt, and is taken up again from moist air. But whatever its mode of union may be, the amount of water corresponds to the simple molecular ratio which is indicated in the formula of the species. One molecule of analcite holds a certain definite number of water molecules, and Friedel's observations are not incompatible with the idea that these are retained with varying degrees of tenacity. This idea is suggested by the various series of fractionation experiments which have been made from time to time by independent workers, even though the data are not by any means concordant. Thus Lepierre[1] found that half the water of analcite was driven off at or below 300°, the other half above 440°. In our own experiments three-fourths were expelled at 300°, the remaining fourth being held up to a much higher but undetermined temperature. In both series the water fractions are representable by fourths, but Friedel's experiments[2] indicate a continuity of loss in weight of quite a dissimilar order. Friedel holds that all of the water fractionations heretofore made upon analcite are fallacious, and that no definite fractions can be identified, a conclusion strongly supported by his own data, even though the proof is not absolutely positive. The most that can be said is that the weight of evidence so far is in favor of Friedel's contention, but that additional investigation is necessary in order to reconcile all discrepancies. The full significance of the water in analcite remains unknown.

In order to discuss the constitution of analcite, let us recur to the analysis of the mineral itself. It is at once evident from the comparison made on a preceding page that our sample of the mineral varies notably in composition from the requirements of theory. The silica is 2.5 per cent too high, while alumina and soda are correspondingly low. No probable impurity and no presumable errors of manipulation can

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[1] Bull. Soc. chimique, Paris, 3d series, Vol. XV, 1896, p. 561.
[2] Bull. Soc. min., Vol. XIX, 1896, p. 363.

account for so great a divergence. If we consult other analyses, as we find them tabulated in manuals like those of Dana and of Hintze, we shall find other cases resembling this, and also examples of variation in the opposite direction, with silica low and an apparent excess of bases. Most analcite gives quite sharply the metasilicate ratios required by the accepted formula; but the variations from it are large enough, common enough, and regular enough to command attention. The analyses are not all covered by the recognized theory, and the apparent irregularities are not fortuitous, but are systematic in character.

One explanation of the seeming anomalies is simple and clear. If analcite, instead of being a metasilicate, is really a mixture of ortho- and trisilicate, then all of the analyses became intelligible. In most cases the two salts are commingled in the normal ratio of one to one; but in our analcite the trisilicate predominates, while in some other samples the orthosalt is in excess. All reduce alike to the simple expression

$$NaAlX. H_2O,$$

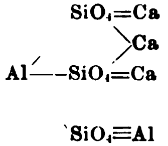
in which X represents $nSiO_4+mSi_3O_8$; a formula which agrees with evidence from various other sources.

For example, analcite may be derived in nature either from albite, $AlNaSi_3O_8$, or nephelite, $AlNaSiO_4$, and, on the other hand, alterations of it into feldspars have been observed. Its closest analogue, leucite, has yielded pseudomorphs of orthoclase and elæolite; while leucite and analcite are mutually convertible each into the other. The evidence of this character, the evidence of relationship between analcite and other species, is varied and abundant, and the simplest conclusion to be drawn from it is that which has been given. Every alteration, every derivation, every variation in the composition of analcite points to the same belief. The consistency of the data can not well be denied.

In the case of a normal analcite—that is, one which conforms to the usual empirical formula—the expression which best represents these relations is

$$Al_4Na_4(SiO_4)_2\,(Si_3O_8)_2\,.\,4H_2O;$$

and this accords with the minimum molecular weight as determined by the study of our ammoniated residue. Structurally, this is comparable with the formulæ of garnet, zunyite, sodalite, nosite and leucite; all of which are also isometric in crystallization. The more important of the symbols are as follows: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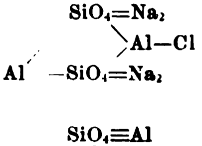
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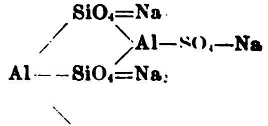
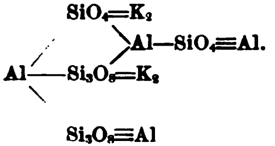
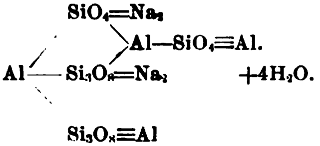

Nosite.



Leucite.



Analcite.

That is, analcite and leucite become members of the garnet-sodalite group of minerals, and their relations to nephelite, albite, prehnite, natrolite, etc., natural and artificial, are perfectly clear. In analcite there may be admixtures of strictly analogous ortho- or trisilicate molecules; but these remain to be separately discovered.

Now, these formulæ are not ultimate verities to be blindly accepted. They are simply expressions which represent composition and a wide range of established relationships, and which serve a distinct purpose in the correlation of our knowledge. Properly used, with due recognition of their limitations, they are helpful, and suggest possibilities of research; misused, they may become mischievous. They now satisfy all known conditions, and that is a sufficient warrant for their existence.

THE CONSTITUTION OF TOURMALINE.

By F. W. Clarke.

Some years ago, in an extended paper upon the constitution of the silicates,[1] I proposed a formula for tourmaline which seemed to satisfy all known conditions. Recently Penfield and Foote[2] have offered still another interpretation of the analyses, and support their views with a considerable weight of argument. The appearance of their paper has led me to rescrutinize the evidence more in detail than previously, and the result has been to modify my formulæ in some particulars while retaining them in their general form.

According to Penfield and Foote all tourmaline may be represented as salts of the alumino-borosilicic acid $H_{11}Al_3B_2Si_4O_{21}$, in which two hydroxyls are permanently linked to boron, leaving an available valency or basicity of nine. In my formulæ all tourmalines are derived from the similar acid $H_{14}Al_5B_3Si_6O_{31}$, with all of the hydrogen atoms replaceable by bases. Upon bringing the two acids to the common basis of six silicon atoms, they compare as follows:

Penfield and Foote	$H_{16\frac{1}{2}}Al_{4\frac{1}{2}}B_3Si_6O_{31\frac{1}{2}}$
Clarke	$H_{14}Al_5B_3Si_6O_{31}$

Replacing aluminum by hydrogen, in order to show the ultimate acids, these expressions become

Penfield and Foote	$H_{30}B_3Si_6O_{31\frac{1}{2}}$
Clarke	$H_{29}B_3Si_6O_{31}$

The small difference between the empirical formulæ is thus made evident, and it hardly amounts to more than the uncertainties in the analyses. In fact, the trustworthy analyses of tourmaline give ratios lying between and beyond both extremes, as the following formulæ, computed from Riggs's data, show: In these expressions fluorine has been assumed equivalent to hydroxyl.

Pierrepont, black	$H_{30.07}B_{2.93}Si_6O_{30.83}$
Paris, black	$H_{30.73}B_{3.16}Si_6O_{31.35}$
Stony Point, black	$H_{31.23}B_{3.02}Si_6O_{31.03}$
Auburn, colorless	H[illegible]$B_{2.77}Si_6O_{30.73}$
Brazil, red	$H_{31.78}B_{2.77}Si_6O_{31.56}$
Gouverneur, brown	$H_{29.88}B_{2.96}Si_6O_{30.61}$
Hamburg, brown	$H_{30.63}B_{3.16}Si_6O_{32.14}$

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[1] Bull. U. S. Geol. Survey No. 125, 1895.

[2] Am. Jour. Sci., 4th series, Vol. VII, 1899, p. 97.

The two analyses by Penfield and Foote, however, conform sharply to their formula, thus:

De Kalb, white	$H_{29.85}B_{3.03}Si_6O_{31.48}$
Haddam Neck, green	$H_{29.98}B_{3.08}Si_6O_{31.59}$

The Gouverneur and Hamburg tourmalines represent the extreme range of variation; a variation which is too large to be safely set aside as due to analytical errors or to impurities in the material analyzed. Some of the formulæ approximate to mine, some to that of Penfield and Foote, and hence it seems probable that neither formula, without some qualification, can safely be taken as final.

In order to be satisfactory, a constitutional formula must fulfill several conditions. First, it must adequately express the composition of the compound in question, covering all of its variations. Second, it must be readily applicable to the full discussion of analyses, so that the different isomorphous salts which are commingled in a mineral species can be separately identified and given reasonable expressions. Finally, it should indicate the relations between a species and the other minerals with which it is allied, or into which it commonly alters. A formula can be fully adopted only when all of these conditions are satisfied. The third condition, which relates to function, is equally important with the other two.

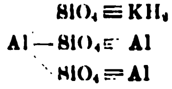
With the tourmalines, the micas seem to be most nearly akin. In each group we have to consider comminglings of isomorphous molecules, and when tourmaline alters, a mica is commonly the product of the reaction. In composition, also, the two groups show an apparent parallelism. With the lithia mica, lepidolite, lithia tourmalines occur; with muscovite and biotite, the common iron tourmaline is associated; and the magnesian tourmalines, which show the minimum of alumina in their composition, are similarly allied to phlogopite. This relationship, if it is real, should be suggested in the formulæ assigned to the several species.

To the commoner micas a simple series of formulæ can be easily given, thus:

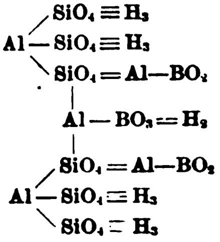
Muscovite	$Al_3(SiO_4)_3KH_2$,
Biotite	$Al_2(SiO_4)_3Mg_2KH$,
Phlogopite	$Al_1(SiO_4)_3Mg_3KH_2$;

and to these types, or mixtures of them, most micas are referable. The variations and exceptions have been considered elsewhere, and need not be discussed here.

With these fundamental molecules the corresponding salts of the tourmaline acid $H_{29}B_3Si_6O_{31}$, or $H_{14}Al_5B_3Si_6O_{31}$ are structurally correlated. The subjoined formulæ are sufficient to make this point clear; and to render the splitting up of tourmaline, its alteration into mica, somewhat intelligible.



Muscovite



The tourmaline acid.

In the acid, two hydrogen atoms are united with the orthoboric group, and twelve with the orthosilicate portion of the nucleus. Hence, to avoid repetition of the structural expression, the formula may be condensed into a linear form, as follows:

$$Al_5(SiO_4)_6(BO_2)_2 \,.\, BO_3H_2 \,.\, H_{12},$$

and this is applicable to the discussion of the analyses. For example, Riggs's analysis of the black magnesium tourmaline from Pierrepont, New York, corresponds to the following molecular mixture:

$$\begin{array}{ll} 18. & Al_5(SiO_4)_6(BO_2)_2 \,.\, BO_3Ca \,.\, Mg_4H_4 \\ 7. & Al_5(SiO_4)_6(BO_2)_2 \,.\, BO_3Mg \,.\, Mg_4H_4 \\ 2. & Al_5(SiO_4)_6(BO_2)_2 \,.\, BO_3Na_2 \,.\, AlNa_4H_5 \end{array}$$

Comparing this with the analysis, and reducing the latter by union of like bases and recalculation to 100 per cent, we have—

	Found.	Reduced.	Calculated.
SiO_2	35.61	37.19	37.05
B_2O_3	10.13	10.51	10.80
Al_2O_3	25.29	27.10	27.19
Fe_2O_3	.44		
TiO_2	.35		
CaO	3.31	3.45	3.40
FeO	8.19		
MgO	11.07	16.31	16.28
Na_2O	1.51	1.72	1.74
K_2O	.20		
H_2O	3.34	3.72	3.54
F	.27		
	99.55	100.00	100.00

The result is evidently satisfactory. In dealing with titanium I have followed Penfield, regarding it as really Ti_2O_3 and equivalent to alumina. The fluorine is treated as replacing hydroxyl, and is, therefore, united with the water. It is possible, however, that fluorine may sometimes replace the group BO_2, an equivalency which is strongly indicated in the cappelenite group of minerals.

The brown tourmaline from Gouverneur, New York, as analyzed by Riggs, also reduces to a similar mixture of molecules, and its composition may be written thus:

5. $Al_5(SiO_4)_6(BO_2)_2 . BO_3Ca . Mg_4H_4$,
3. $Al_5(SiO_4)_6(BO_2)_2 . BO_3Mg . Mg_4H_4$,
2. $Al_5(SiO_4)_6(BO_2)_2 . BO_3NaH . Al_2Na_2H_4$;

and the comparison between analysis and theory is as follows:

	Found.	Reduced.	Calculated.
SiO_2	37.39	37.54	37.32
B_2O_3	10.73	10.76	10.88
Al_2O_3	27.79	28.72	28.53
Fe_2O_3	. . 10		
TiO_2	1.19		
FeO	.64		
MgO	14.09	14.51	14.52
CaO	2.78	2.79	2.90
Na_2O	1.72	1.83	1.93
K_2O	.16		
H_2O	3.83	3.85	3.92
	100.42	100.00	100.00

By consolidating lime with magnesia the expressions for both tourmalines might be simplified; but in other cases this would not be warranted. In some tourmalines calcium seems rather to replace sodium, or else the group NaH, a probability which will appear later.

In these two tourmalines the theoretical silicon-oxygen ratio Si_6O_{31} is assumed, in accordance with my original formula. We may now consider the cases in which that ratio is exceeded, with more or less approach to the formula proposed by Penfield and Foote. This condition is easily satisfied by regarding one of the component salts of tourmaline as slightly basic, containing the bivalent group $=Al-O-H$ or $=Al-F$ as an essential factor. With this assumption, which recognizes the equivalency of hydroxyl and fluorine, the analyses reduce to the general type indicated in the two preceding examples. For instance, the white tourmaline from De Kalb, New York, has the following composition:

10. $Al_5(SiO_4)_6(BO_2)_2 . BO_3(AlOH) . Mg_4H_4$.
20. $Al_5(SiO_4)_6(BO_2)_2 . BO_3Ca . Mg_4H_4$.
3. $Al_5(SiO_4)_6(BO_2)_2 . BO_3Na_2 . Al_3Na_3$.

For comparison the analyses by Penfield and Foote and by Riggs are available. In this case the minute quantities of titanium are ignored.

	Found.		Reduced.			Calculated.
	P. and F.	Riggs.	P. and F.	Riggs.	Mean	
SiO_2	36.72	36.88	36.56	36.81	36.69	36.79
TiO_2	.05	.12	....	....	....	....
B_2O_3	10.81	10.58	10.76	10.56	10.66	10.74
Al_2O_3	29.68	28.87	29.55	28.81	29.18	29.07
FeO	.22	.52				
MgO	14.92	14.53	14.97	14.79	14.88	14.86
CaO	3.49	3.70	3.47	3.69	3.58	3.48
Na_2O	1.26	1.39	1.28	1.50	1.39	1.44
K_2O	.05	.18				
H_2O	2.98	3.56	3.41	3.84	3.62	3.62
F	.93	.50				
	101.11	100.83	100.00	100.00	100.00	100.00

The dark brown tourmalines from Orford, New Hampshire, and Monroe, Connecticut, as analyzed by Riggs, also reduced to similar form, and approximate to the mixture

15. $Al_6(SiO_4)_6(BO_2)_2 . BO_3(AlOH) . Mg_4H_4$,
6. $Al_6(SiO_4)_6(BO_2)_2 . BO_3Ca . Mg_4H_4$,
8. $Al_6(SiO_4)_6(BO_2)_2 . BO_3NaH . Al_3Na_3H$,

with the comparison as follows:

	Found.		Reduced.		Calculated.
	Orford.	Monroe.	Orford.	Monroe.	
SiO_2	36.66	36.41	36.96	37.34	36.84
B_2O_3	10.07	9.65	10.16	9.89	10.74
Al_2O_3	32.84	31.27	33.28	33.13	33.11
TiO_2	.23	1.61			
FeO	2.50	3.80			
MgO	10.35	9.47	11.84	11.88	11.85
CaO	1.35	.98	1.36	1.00	1.19
Na_2O	2.42	2.68	2.58	2.88	2.62
K_2O	.22	.21			
H_2O	3.78	3.79	3.82	3.88	3.65
	100.42	99.87	100.00	100.00	100.00

Here the divergence between the composition as found and as calculated is evidently due to the low determinations of boric acid in the analyses. Still the comparison is close.

Between the magnesium tourmalines and the iron tourmalines the closest analogy exists, and the identity of type is absolute. Taking, except when otherwise specified, the analyses by Riggs, all the iron tourmalines reduce to mixtures of the following isomorphous molecules:

A. $Al_5(SiO_4)_6(BO_2)_2 . BO_3(AlOH) . Fe_4H_4,$
B. $Al_5(SiO_4)_6(BO_2)_2 . BO_3Ca . Fe_4H_4,$
C. $Al_5(SiO_4)_6(BO_2)_2 . BO_3NaH . Al_3NaH_2,$
D. $Al_5(SiO_4)_6(BO_2)_2 . BO_3NaH . Al_3Na_2H,$
E. $Al_5(SiO_4)_6(BO_2)_2 . BO_3NaH . Al_3Na_3.$

Molecules C, D, and E are evidently identical, except in the varying replacements of sodium by hydrogen. A and B are similarly alike, so that actually only two fundamental compounds are assumed. From the commoner iron tourmalines lime is practically if not quite absent; and these may be interpreted very nearly as mixtures of A and C, such as A_8C_5, A_7C_5, etc. If we take the minute quantities of lime into account, the black tourmalines from Brazil and from Stony Point, North Carolina, correspond to $A_{13}B_2C_9$; that from Auburn, Maine, to $A_{35}B_2C_{27}$, and that from Paris, Maine, to $A_{10}B_1C_9$. It will be noticed that the molecule A is in excess of the other two, a condition which fits the analyses, but which is incompatible with the formula proposed by Penfield and Foote. To satisfy the latter the number of A molecules should be exactly equal to B + C, giving the ratio Si_4O_{21} or $Si_6O_{31\frac{1}{2}}$. The analyses in question are as follows:

	Brazil.	Stony Point.	Auburn.	Paris.
SiO_2	34.63	35.56	34.99	35.03
B_2O_3	9.63	10.40	9.63	9.02
TiO_2	....	.55	....	....
Al_2O_3	32.70	33.38	33.96	34.44
Fe_2O_3	.31	....	....	1.13
FeO	13.69	8.49	14.23	12.10
MnO	.12	.04	.06	.08
MgO	2.13	5.44	1.01	1.81
CaO	.33	.53	.15	.24
Li_2O	.08	trace	....	.07
Na_2O	2.11	2.16	2.01	2.03
K_2O	.24	.24	.34	.25
H_2O	3.49	3.63	3.62	3.69
F	.06	....	....	....
	99.52	100.42	100.00	99.89

The reduced analyses and their comparison with the calculated composition is as follows:

	Found. Stony Point.	Found. Brazil.	Calculated. $A_{12}B_2C_9$.	Found. Auburn.	Calculated. $A_{25}B_2C_{27}$.	Found. Paris.	Calculated. $A_{10}B_1C_9$.
SiO_2	34.10	34.26	34.27	34.75	34.48	34.70	34.62
B_2O_3	9.98	9.54	9.99	9.56	10.06	8.94	10.10
Al_2O_3	32.37	32.54	32.36	33.73	33.28	34.82	33.60
FeO..........	17.33	17.45	17.14	15.99	15.95	15.30	15.23
CaO	.52	.33	.45	.15	.17	.25	.27
Na_2O	2.22	2.40	2.22	2.23	2.50	2.33	2.67
H_2O..........	3.48	3.48	3.57	3.59	3.56	3.66	3.51
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Here again the agreements between analysis and theory are as close as could be reasonably expected. The same thing is true of the black tourmalines from Haddam Neck, Connecticut, and Nantic Gulf. Using letters to represent the several molecules, as above, the Haddam mineral is sharply represented by $A_4B_1D_2$, and that from Nantic Gulf by $A_6B_7C_3E_1$. Here is the comparison:

	Haddam Neck.			Nantic Gulf.		
	Found.	Reduced.	Calculated.	Found.	Reduced.	Calculated.
SiO_2	34.95	33.78	33.67	35.34	33.34	33.60
B_2O_3	9.92	9.60	9.82	10.45	9.86	9.80
TiO_2	.57	30.74	30.67	.40	29.01	28.84
Al_2O_3	31.11			30.49		
Fe_2O_3	.50			....		
FeO	11.87	19.31	19.24	8.22	20.46	20.55
MnO	.09			trace		
MgO	4.45			7.76		
CaO	.81	.78	.75	2.32	2.19	2.15
Na_2O........	2.22	2.30	2.48	1.76	1.74	1.70
K_2O..........	.24			.15		
H_2O..........	3.62	3.49	3.37	3.60	3.40	3.36
	100.35	100.00	100.00	100.49	100.00	100.00

To the lithia tourmalines, as analyzed by Riggs, a similar set of formulæ apply, although the comparison between fact and theory is not quite so close as in the preceding cases. The red tourmalines from Brazil and from Rumford, Maine, are very nearly represented by the expression

$$Al_5(SiO_4)_6(BO_2)_2 . BO_3R'H . Al_3R'H_2;$$

with Li : Na approximately as 5 : 4. The slight deficiency in the alkalies is made up by the presence of small amounts of calcium, iron, and manganese, but the ratio $Al_8 : Si_6$ is very clear. The green tourmalines are all lower in alumina, and range downward toward the iron end of the series; and like the latter are representable as mixtures of the following molecular types:

A. $Al_5(SiO_4)_6(BO_2)_2 . BO_3(AlOH) . Fe_1H_4$.
B. $Al_5(SiO_4)_6(BO_2)_2 . BO_3Ca . Fe_4H_4$.
C. $Al_5(SiO_4)_6(BO_2)_2 . BO_3LiH . Al_2Li_2H_4$.
D. $Al_5(SiO_4)_6(BO_2)_2 . BO_3NaH . Al_3NaH_2$.
E. $Al_5(SiO_4)_6(BO_2)_2 . BO_3H_2 . Al_3NaH_2$.

Thus the dark, opaque green tourmaline from Rumford, Maine, is a molecular mixture corresponding to $A_6B_2C_7D_{14}E_5$; the similar mineral from Auburn is $A_8B_1C_8D_{17}$; the light green from Auburn, $A_2CB_{310}D_8E_{12}$, and the nearly colorless from Auburn, $A_1B_5C_{20}D_{10}E_{35}$. From Brazil the dark green is $A_2B_1C_6D_8$, and the light green is $A_1B_2C_9D_8E_5$. The complexity of these expressions is only apparent, not real, as a study of the original type formulæ will show. They compare with the reduced analyses as follows:

	Rumford.		Auburn, dark.		Auburn, medium.	
	Found.	Calculated.	Found.	Calculated.	Found.	Calculated.
SiO_2	36.68	36.69	36.37	36.45	37.95	37.52
B_2O_3	10.26	10.69	9.98	10.63	10.57	10.94
Al_2O_3	38.26	37.74	36.89	37.21	38.11	39.02
FeO	6.78	6.90	7.94	7.72	4.47	4.28
CaO	.34	.34	.17	.16	.50	.50
Na_2O	3.12	3.07	3.19	3.14	2.58	2.58
Li_2O	.95	.94	1.06	1.07	1.35	1.35
H_2O	3.61	3.63	4.40	3.62	4.47	3.81
	100.00	100.00	100.00	100.00	100.00	100.00

	Auburn, pale.		Brazil, dark.		Brazil, light.	
	Found.	Calculated.	Found.	Calculated.	Found.	Calculated.
SiO_2	38.25	37.92	37.24	37.14	37.49	37.64
B_2O_3	10.30	11.05	9.95	10.83	10.32	10.97
Al_2O_3	39.92	40.17	38.66	38.07	39.86	39.04
FeO	2.75	2.56	5.49	5.24	3.74	3.61
CaO	.43	.49	.39	.35	.49	.46
Na_2O	2.55	2.53	2.90	3.01	2.59	2.76
Li_2O	1.34	1.34	1.63	1.64	1.71	1.69
H_2O	4.46	3.94	3.74	3.72	3.80	3.83
	100.00	100.00	100.00	100.00	100.00	100.00

In these cases the low boric acid of the analyses and the uncertainties as to the significance of the water determinations account for the chief variations between observation and theory. There is another complication also, due to the fact that alternative expressions are possible between which it is very difficult to decide. In the tourmaline from Haddam Neck, Connecticut, analyzed by Penfield and Foote, a somewhat different commingling of molecules seems to be necessary, partly on account of the higher proportion of lime in the mineral and partly on account of the fluorine. This tourmaline also admits of various alternatives in formulation, but it agrees well with the molecular mixture—

3. $Al_5(SiO_4)_6(BO_3)_2 . BO_3Ca . Fe_4H_4$,
10. $Al_5(SiO_4)_6(BO_3)_2 . BO_3(AlOH) . Al_2Li_2H_4$,
1. $Al_5(SiO_4)_6(BO_3)_2 . BO_3Ca . Al_3NaH_2$,
6. $Al_5(SiO_4)_6(BO_3)_2 . BO_3NaH . Al_3NaH_2$;

in which Ca is equivalent to a replacement of NaH. This mixture, with the group AlOH proportional to fluorine, gives a good comparison between analysis and theory, thus:

	Found.	Reduced.	Calculated.
SiO_2	36.96	36.75	36.86
B_2O_3	11.00	10.94	10.74
TiO_2	.03		
Al_2O_3	39.56	39.35	39.44
FeO	2.14	4.35	4.43
MnO	2.00		
MgO	.15		
CaO	1.28	1.27	1.15
Na_2O	2.10	2.09	2.07
Li_2O	1.64	1.63	1.54
H_2O	3.10	3.62	3.77
F	1.13		
	101.09	100.00	100.00

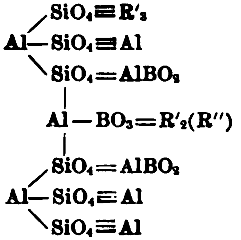
The theoretical amount of fluorine needed to replace hydroxyl in the assumed group, AlOH, is 0.97 per cent. Altogether, the comparison is fairly satisfactory.

One analysis by Riggs, that of the magnesium tourmaline from Hamburg, New Jersey, I have omitted from my discussion. In that tourmaline there are variations which I can not readily account for, unless by assuming the presence in it of a molecule

$$Al_5(SiO_4)_6(BO_3)_2 . BO_3R'_3 . R''_6.$$

Such a molecule, written structurally, exhibits affinities to garnet rather than to the micas; and I prefer to await further evidence before committing myself to any definite formulation in this instance. As for the analyses published by Jannasch and Kalb, they fit in well with those of Riggs, and are amenable to the same treatment.

At first glance some of the formulæ which I have proposed may seem to be complex; but they are all of the same type, and can be reduced to a few général expressions, as follows: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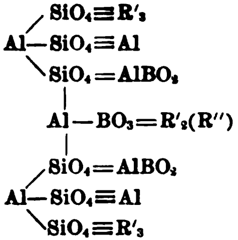
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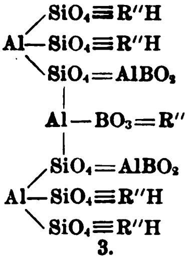
3.

These formulæ cover all of the established variations in the composition of tourmaline; they render the various replacements or isomorphous admixtures intelligible, and they indicate the directions into which the species commonly alters. There is one objection to them, namely, that one of the end products contains no alkali metal, and no alkali-free tourmaline is known. The same objection applies to the Penfield-Foote formula, as will be seen by anyone who attempts to apply it in the discussion of the iron tourmalines. Under either system of formulation the existence in tourmaline of alkali-free salts must be assumed.

One further possible advantage in the proposed formulæ remains to be pointed out. All of the chemists who of late years have discussed the composition of tourmaline agree in adopting the ratio between silicon and boron of 2 : 1, or $4SiO_2 : B_2O_3$. And yet many of the analyses vary from this ratio to an extent which may not be due to experimental errors. For example, from among Riggs's analyses the following cases show large variations, the boron being too low. I give the silica and boric oxide as determined, the boric oxide as calculated from the silica by the accepted ratio, and the amount of variation between the two.

	SiO_2.	B_2O_3 found.	B_2O_3 calculated.	Difference.
Rumford, red	38.07	9.99	11.10	—1.11
Paris, black	35.03	9.02	10.22	—1.20
Monroe, brown	36.41	9.65	10.62	—0.97
Brazil, green	36.91	9.87	10.76	—0.89
Auburn, colorless	38.14	10.25	11.12	—0.87

In the analyses by Jannasch and Kalb the following examples are very striking:

	SiO_2.	B_2O_3 found.	B_2O_3 calculated.	Difference.
Snarum	35.64	9.93	10.40	—1.47
Mursinka	34.88	8.94	10.17	—1.23
Buckworth	35.50	8.34	10.35	—2.01
Brazil	37.05	9.09	10.81	—1.72

It would hardly be wise to dismiss these variations as due to errors, especially when the summation of the analyses is good and the analysts are known to be trustworthy. Such errors on the part of either Jannasch or Riggs would be almost incredible, and I am therefore inclined to believe that the analyses are good, and that we should seek a cause for the variations. In my scheme of formulation the bivalent group of atoms $=Al-BO_2$ occurs. Replace this in part by the similar groups $=Al-OH$ and $=Al-F$, and the variations are accounted for. This supposition satisfies the analyses completely, and covers the ground. It is in accord with all the evidence, even though its validity may not be definitely proved. By its application to the discussion of the analyses the divergencies between the calculated composition and the composition as found can be notably diminished.

But although the formulæ which I have adopted serve to express the composition of all tourmalines, they still leave room for alternatives. Penfield and Foote, as well as myself, assume that tourmaline is a mixed salt containing distinct boric and silicic radicles. Future investigation may prove that it is really derived from a complex boro-silicic acid, as yet unknown; and the same conception may be true of other species, such as axinite, datolite, danburite, cappelenite, etc. A series of borosilicic acids is theoretically conceivable; and until this question has been considered, the constitution of all the minerals above mentioned must be regarded as unsettled.

THE COLORIMETRIC ESTIMATION OF SMALL AMOUNTS OF CHROMIUM, WITH SPECIAL REFERENCE TO THE ANALYSIS OF ROCKS AND ORES.

By W. F. HILLEBRAND.

INTRODUCTION.

In the analysis of a number of highly titaniferous magnetites containing chromium, phosphorus, and vanadium, the satisfactory separation of all these bodies in a form fit for separate determinations became a serious problem. The method of T. Fischer[1]—digestion of the precipitated lead salts with a strong solution of potassium carbonate—appears to offer the long-needed satisfactory quantitative separation of arsenic, phosphorus, chromium, tungsten, and molybdenum from vanadium, the normal lead meta-vanadate remaining quite unattacked, according to the author, while the other lead salts are wholly decomposed, but the applicability of this method to the separation of the minute amounts often found in rocks and ores has not been tested. The time required is considerable, hence it was desirable to devise a more rapid way for determining both chromium and vanadium without resorting to this separation. That this object has been measurably achieved, with certain limitations as to vanadium, the work thus far done seems to indicate. The present paper will deal only with the rapid estimation of chromium either in absence or presence of any or all of the elements above mentioned.

In view of the high coloring power of the chromates, it is surprising that so little use has been made of this property as the basis for a quantitative method for the estimation of chromium. A search through some of the more important text-books has revealed no reference to such a method, although L. de Koningh[2] has successfully applied it in the analysis of articles of food. Yet the results attainable by colorimetric comparisons of dilute alkaline solutions of unknown strength with those of a known standard leave little to be desired in point of quantitative accuracy.

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[1] Inaugural Dissertation, Rostock, 1894.

[2] Nederl. Tÿdsch. voor Pharmacie, Chemie, en Toxicologie, 1889, p. 257.

As with colorimetric methods in general this one gives better results with small than with large percentages of chromium, yet it can be applied in the latter cases with very fairly satisfactory results by making a larger number of consecutive comparisons with the same solution.

OUTLINE OF METHOD.

The chromium is brought into a measured volume of solution as monochromate rendered alkaline by sodium carbonate, and the whole or a portion of this solution is then compared with a definite amount of a somewhat stronger standard, likewise made alkaline with sodium carbonate. The latter is diluted with water till both seem to be exactly alike in color, when a simple calculation gives the amount of chromium sought. The actual comparison takes little time, and any number of repetitions can be made if desired in order to secure greater accuracy from the mean of a large number of observations. The preparation of the solution to be tested offers nothing novel, but certain precautions have to be observed therein as well as in the color comparisons which will be touched upon later.

TESTING OF METHOD BY COMPARISON OF STANDARD SOLUTIONS.

Two standard solutions were prepared by dissolving 0.25525 and 0.5105 gram potassium chromate in 1 liter of water made alkaline by a little sodium carbonate, each cubic centimeter then corresponding respectively to 0.1 and 0.2 milligram chromic oxide, in which latter form chromium is usually reported in rocks and ores. Definite amounts of one of the standards were then diluted with varying amounts of water in a tall, square glass vessel with exactly parallel sides. Into an exact duplicate of this vessel 5 cubic centimeters or more of the standard were introduced from a burette and diluted with water from another burette till exact agreement seemed to be reached on looking through the glasses horizontally.

In the following tables are recorded all observations without regard to the sequence in which they were made. No greater pains were taken to get exact agreement of color than are ordinarily observed in our routine titanium estimations, which are carried out in a precisely similar manner, so that the results may be taken to represent everyday work without extreme precautions. In only two cases can the observations be considered really bad, viz, the third comparison of No. 6 and the first of No. 16.

TABLE I.

[Ten cubic centimeters standard represent 1 milligram chromic oxide.]

No.	Test solution.		Comparison standard.		Contents as chromic oxide.	Chromic oxide found.	Chromic oxide present.	Error.	Chromic oxide found.
	Standard.	Diluted with water.	Cubic centimeters.	H_2O added.					
	c. c.	c. c.		c. c.	Mgs.	Mgs.	Mgs.	Mgs.	Per cent.
1	[a]10	[a]90	5	44.00	0.5	0.98	1	—0.02	98.0
2	[b]20	[b]80	5	21.00	.5	1.92	2	— .08	96.0
3	40	60	10	14.60	1.0	4.06	4	+ .06	101.5
4	40	60	9.7	14.25	.97	4.05	4	+ .05	101.2
			10	13.95	1.0	4.17	4	+ .17	104.4
			10	14.30	1.0	4.11	4	+ .11	102.9
			10	14.20	1.0	4.13	4	+ .13	103.3
5	40	60	10	14.65	1.0	4.05	4	+ .05	101.4
			10	15.65	1.0	3.90	4	— .10	97.5
6	40	60	10	15.25	1.0	3.96	4	— .04	99.0
			10	14.30	1.0	4.11	4	+ .11	102.9
			10	13.15	1.0	4.32	4	+ .32	108.0
			10	14.75	1.0	4.04	4	+ .04	101.0
			20	29.50	2.0	4.04	4	+ .04	101.0
7	50	50	10	9.75	1.0	5.06	5	+ .06	101.2
8	50	50	10	10.00	1.0	5.00	5	.00	100.0
9	60	40	10	7.20	1.0	5.81	6	— .19	96.7
10	75	25	20	6.65	2.0	7.505	7.5	+ .005	100.1
			20	6.60	2.0	7.519	7.5	+ .019	100.2
			10	3.15	1.0	7.605	7.5	+ .105	101.4
			15	4.70	1.5	7.610	7.5	+ .11	101.5
11	10	10	10	10.15	1.0	0.992	1	— .008	99.2
			20	19.75	2.0	1.006	1	— .006	100.6
12	10	11	10	10.60	1.0	1.02	1	+ .02	102.0
13	14.2	26.9	10	18.60	1.0	1.43	1.42	+ .01	100.7
			20	35.70	2.0	1.47	1.42	+ .05	103.5
14	15	24.35	10	16.55	1.0	1.48	1.5	— .02	98.7
15	16	20	10	13.30	1.0	1.54	1.6	— .06	96.2
			20	24.30	2.0	1.63	1.6	+ .03	101.9
16	31.9	20.6	10.5	8.10	1.05	2.96	3.19	— .23	92.8
			20.5	14.20	2.05	3.10	3.19	— .09	97.2
17	62.05	22.3	20	7.00	2.0	6.25	6.205	+ .45	100.7
			40	12.00	4.0	6.49	6.205	+ .285	104.6

Mean percentage found, 100.5.

[a] Color in this dilution too faint.

[b] Limit of dilution for clear distinction of color in a thickness of 3.3 cm.

TABLE II.

[Varying amounts of standard No. 2 (1 c. c. = 0.2 mg. Cr_2O_3) diluted till of the same concentration as standard No. 1.]

No.	Standard.			Chromic oxide found per 100 c. c.	Chromic oxide present in 100 c. c.	Error.	Chromic oxide found.
	Cubic centimeters.	Water added.	Contents as chromic oxide.				
		c. c.	*Mgs.*	*Mgs.*	*Mgs.*	*Mg.*	*Per cent.*
18	5	5.2	1	9.80	10	−0.2	98.0
19	10	9.95	2	10.02	10	+ .02	100.2
20	15	15.8	3	9.74	10	− .26	97.4
21	20	20.0	4	10.00	10	.00	100.0
22	30	29.5	5	10.08	10	+ .08	100.8

Mean percentage found, 99.3; grand mean, 100.36.

The first table and the grand mean show an apparent personal tendency toward slightly high results, though it is possible that this is due to a slight difference in the internal dimensions of the two glasses, the same one always having been used for the standard solution. If this is so, a long series of tests with glasses reversed should give a general mean slightly below 100.

TESTING THE METHOD ON ORES AND ROCKS.

In order to prove the value of the method in rock analysis, varying amounts of the standard solution were evaporated in a large crucible with 5 grams of an iron ore carrying phosphorus and vanadium, and fused with 20 grams of sodium carbonate and 3 grams sodium nitrate. The aqueous extract, after reduction of manganese by methyl or ethyl alcohol, was nearly neutralized by nitric acid and evaporated to secure approximate separation of silica and alumina. As a precautionary measure, since a little chromium is usually carried down, the precipitate was ignited, silica was removed by hydrofluoric and sulphuric acids, the residue was fused with sodium carbonate, and alumina again separated as before. To the combined filtrate was added mercurous nitrate, and the slightly washed copious precipitate of phosphate, chromate, vanadate, and carbonate of mercury was ignited with the paper in a platinum crucible, which can be done without much fear of loss or of injury to the crucible. The residue was then fused with a little sodium carbonate, extracted with water, filtered into a graduated flask and made up to 50 or 100 cubic centimeters, according to the intensity of the color, and compared with the standard. A similar operation was carried out with a silicate rock. Table III shows the results.

TABLE III.

No.		Chromic oxide added.	Chromic oxide found.
		Milligrams.	*Milligrams.*
I.	Five grams iron ore	7.03	7.18
		....	7.20
		....	7.25
		....	7.21
II.	Five grams iron ore	2.99	3.08
		....	3.13
III.	Two grams silicate	1.6	1.53
		....	1.57
		....	1.59

When the percentage of chromic oxide in an ore or mineral is more than about 0.2 per cent, and vanadium has not also to be estimated, much time may be spared by at once taking the color of the original extract from the sodium carbonate fusion after insuring complete reduction and removal of manganese, and perhaps concentrating. But if the chromium is much less than this amount, and especially if several grams of powder have been operated on, it becomes difficult or impossible to obtain a filtrate of sufficiently small bulk to show a decided color. Therefore, in such cases, and when vanadium is likewise to be estimated, it is necessary to precipitate as above with mercurous nitrate in order to eventually have a small bulk of sufficiently colored solution. Even then, for very minute amounts, it is necessary to use Nessler tubes exactly as in ammonia estimations.

If niter has been used in the fusion and the crucible has been attacked by it, a yellow color of the filtrate may be due to dissolved platinum, but neither the proportion of niter nor the temperature of the blast should ever be high enough to permit the crucible to be attacked.

THE COLORIMETRIC APPARATUS AND ITS USE.

The glasses employed were of approximately square section, about 12 centimeters high and 3.3 centimeters inside measurement, with exactly parallel sides, and of course as nearly alike as they could be obtained. One pair of opposite sides of each should be blackened. With glasses of the thickness mentioned it is generally advisable to use from 5 to 10 cubic centimeters of standard at a time and to so regulate the strength of the solution to be tested that it shall contain more than 2 milligrams chromic oxide in 100 cubic centimeters, which is about the limit of distinct visibility in a thickness of 3.3 centimeters.

In order to exclude the effect of side light in this and other similar methods (titanium, for instance), it is very convenient to have a simple light box that can be easily held in one hand, about 35 centimeter long and 13 to 14 centimeter square, painted black inside and out and with one end closed by a piece of ground glass, the other open. For a space equal to the width of the glasses the cover is removed at the top next the glass end to permit of the insertion of the glasses, side by side, in such a way that no light shall penetrate around their sides or between them. A stiffly sliding, black cardboard shutter is movable up and down immediately back of the glasses, so that all light can be cut off except that which comes through the liquid.

Precautions of this kind are necessary if accurate results are to be counted on. Except for mere traces this simple combination of glasses and darkened box insures greater accuracy and rapidity of work than Nessler tubes and is preferable likewise, so far as my own experience goes, to expensive instruments like the colorimeter of Soleil-Duboscq, etc. The glasses should, of course, have exactly parallel sides and equal diameters, though they may perhaps be made with advantage rather narrow in one direction to permit of using smaller bulks of liquid.

In making the color comparisons the box is best held close to a window, so as to get a full, strong light. The condition of the light seems to make an appreciable difference in the accuracy of the comparisons, all of which were made by daylight.

ACCURACY OF RESULTS.

Especially for comparatively and very small amounts of chromium the method gives exact results, better than can ordinarily be hoped for from any gravimetric method, considering the fact that as a rule other substances are present which it is extremely difficult to remove completely.

A few comparisons between colorimetric and gravimetric determinations of chromium in a few rocks are here given to show the order of agreement, the former having been made several months and even years after the latter:

Gravimetric.	Colorimetric.
Per cent.	*Per cent.*
trace	0.018
0.05	.051
.14	.12
.08	.083
trace	.013
none	.0086
none	.0067

The outcome was somewhat of a surprise, for it was scarcely to be expected that the long and laborious gravimetric separations should have resulted so well as they are shown to have done. It should be mentioned that for the gravimetric tests but 1 or 2 grams at most were used, which accounts for the reported absence of chromium in two instances, this report being based on the lack of color in the aqueous extract of the alkaline fusion after removal of manganese.

No experiments have been made with high percentages, but the tables give with certainty the degree of accuracy even then attainable. Whether the chromic oxide to be estimated is 0.1 per cent or 100 per cent, the percentage result is the same, provided the dilution is alike in each case. For instance, if 99.5 per cent is found in a total solution of 100 cubic centimeters containing 0.01 gram chromic oxide, the same percentage holds if the total volume were 10 liters holding 1 gram chromic oxide.

It is probably inadvisable to increase the strength of the standard much above that of No. 2 above, containing 0.2 milligram chromic oxide in form of potassium chromate to the cubic centimeter.

No tests have been made with other alkaline solutions than sodium carbonate, in order to ascertain if there is a difference in the color intensities for like dilution, nor is it probably important to do so.

VOLUMETRIC ESTIMATION OF VANADIUM IN PRESENCE OF SMALL AMOUNTS OF CHROMIUM, WITH SPECIAL REFERENCE TO THE ANALYSIS OF ROCKS AND ORES.

By W. F. HILLEBRAND.

OUTLINE AND LIMITATIONS OF THE METHOD.

When chromium and vanadium occur together and the former has been estimated colorimetrically as detailed in the preceding paper, the vanadium can in many instances be at once estimated without separating from the chromium by the well-known method of titration with potassium permanganate in sulphuric acid solution after reduction by sulphurous acid and expulsion of all excess of the latter.

The application of the method is subject to one limitation—the chromium must not be present above a certain moderate amount. This limitation is due to the considerable amount of permanganate required to produce a clear transition tint when titrating in a hot solution, as is necessary with vanadium. In a cold solution of chromic sulphate much less permanganate is needed to produce the peculiar blackish tint without a shade of green, which affords a sure indication of excess of permanganate, but in a hot and especially a boiling solution the oxidation of the chromium[1] itself takes place so rapidly that a very large excess of the reagent may be added before a pronounced end-reaction is obtained. Nevertheless, as will be shown, quite satisfactory determinations of as little as 1 or 2 milligrams of vanadium pentoxide can be made in presence of as much as 30 milligrams of chromic oxide.

Inasmuch as chromium is almost never a prominent constituent of the clays, coals, iron ores, and rocks in which vanadium has been thus far reported, the method promises to be of great advantage in rock and ore analysis, where these elements probably frequently occur together, generally with phosphorus and sometimes arsenic. It is not directly applicable in presence of molybdenum, and arsenic must first be removed by hydrogen sulphide if present.

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[1] Storer, through Gmelin-Kraut, Vol. II, pt, 2, p. 290.

TESTING THE METHOD.

A solution of sodium vanadate was prepared by fusing 0.937 gram of pure vanadium pentoxide with sodium carbonate and diluting to 1 liter. Each cubic centimeter contained 0.000937 gram vanadium pentoxide. Of this, sufficient amounts were mixed with varying volumes of a standard solution of potassium chromate. After in some cases determining chromium colorimetrically, sulphuric acid was added, sulphur dioxide gas[1] introduced for a few moments, and the excess of the latter expelled by boiling in a rapid current of carbon dioxide, without which its complete expulsion is difficult. When cooled to from 70°–80° C. the titration was made with very dilute solution of permanganate corresponding to about 1 milligram vanadium pentoxide to the cubic centimeter as calculated from its equivalent in iron. By repeating the reduction and boiling, any number of check tests can be rapidly made in the same solution. The solutions ranged in bulk from 50 to 200 cubic centimeters according to the amounts of chromium added.

With the larger chromium contents the differences in the quantity of permanganate used, according as titration was effected at practically boiling temperature or a somewhat reduced one, were very apparent. In one case, at nearly boiling heat, 10 milligrams of chromic oxide were largely oxidized to chromium trioxide, as shown by the change of color from dark green to yellow. Even at 70°–80° with this amount of chromium the results for vanadium will be too high unless the precaution is taken to ascertain the needed correction by adding permanganate to an equal bulk of hot chromic sulphate solution containing approximately the same amount of chromium. When this is done, however, the results are satisfactory even when as much as 30 milligrams of chromic oxide are present and only 1 or 2 milligrams of vanadium pentoxide.

The following tables contain the results of a considerable number of tests, those in Table II being tabulated separately in order to show the degree of accuracy attainable with a large excess of chromium by applying the correction above mentioned and also the amount of this correction.

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[1] The direct use of a solution of sulphur dioxide or of an alkaline sulphite is inadmissible unless these have been freshly prepared, since after a lapse of time they contain other oxidizable bodies than sulphurous acid or a sulphite. The sulphur dioxide is best obtained as wanted by heating a flask containing a solution of sulphur dioxide, or of a sulphite to which sulphuric acid has been added

TABLE I.—*Test determinations of vanadium in presence of chromium.*

No.	Chromic oxide.	Vanadium pentoxide.	Vanadium pentoxide found.	Error.
	Milligrams.	*Milligrams.*	*Milligrams.*	*Milligrams.*
1	1	9.37	9.22	—0.15
2	1	0.94	1.04	+ .10
			.98	+ .04
3	1.5	5.25	5.49	+ .24
			5.43	+ .19
4	2	5.62	5.5	— .12
			5.5	— .12
5	3	4.68	4.78	+ .10
			4.78	+ .10
			4.83	+ .15
6	3	5.62	5.58	— .04
			5.58	— .04
7	3.5	18.74	18.89	+ .15
			18.97	+ .23
8	6	5.6	6.1	+ .50
9	6	4.68	4.78	+ .10
10	6	5.62	5.58	— .04
11	10	5.62	5.58	— .04
12	10	23.52	23.81	+ .29
			23.71	+ .19
13	10	46.85	46.98	+ .13
			47.20	+ .35
14	25	23.52	23.65	+ .13
			23.75	+ .23
15	87.5	23.52	23.71	+ .19

TABLE II.—*Application of degree of correction for larger amounts of chromium, obtained by adding potassium permanganate to an equal bulk of solution containing a like amount of chromic sulphate.*

No.	Chromic oxide.	Vanadium pentoxide.	Vanadium pentoxide found.		Error.	Volume of solution.
			Uncorrected.	Corrected.		
	Mgs.	*Mgs.*	*Mgs.*	*Mgs.*	*Mg.*	*c.c.*
16	20	0.94	1.59	0.99	+0.05	50–100
17	20	1.87	2.69	2.09	+ .22	50–100
			2.39	1.79	— .08	
			2.59	1.99	+ .12	
18	20	18.74	19.4	18.73	— .01	50–100
			19.3	18.63	— .11	
			19.3	18.63	— .11	
19	30	1.87	2.99	2.14	+ .27	[a]100
			2.79	1.94	+ .07	
			2.79	1.94	+ .07	
			2.69	1.84	— .03	
			2.69	1.84	— .03	
20	30	1.87	2.69	1.79	— .08	200
			2.89	2.09	+ .22	
			2.89	2.09	+ .22	
			2.79	1.89	+ .12	
21	62	46.85	48.60	47.60	+ .75	200

[a] About.

In spite of the fact that the correction in most of the trials of this last table represents a large proportion of the permanganate used, the results must be considered satisfactory in view of the small amount of vanadium present, and they show that the method in competent hands after a little experience affords trustworthy figures.

TESTING THE METHOD ON ROCKS AND ORES.

The following table shows its availability for rocks and ores. Known amounts of both chromium and vanadium were added to an iron ore and to a silicate, both free from arsenic, which were then fused with sodium carbonate and nitrate and further treated as follows: After extracting with water and reducing manganese by alcohol, the silica and alumina were mostly removed by nearly neutralizing with nitric acid and evaporating to near dryness. The washed precipitate was ignited and treated with hydrofluoric and sulphuric acids, the residue fused with sodium carbonate, since it frequently contains a little chromium, and again nearly neutralized, etc. To the combined and slightly alkaline filtrates was added mercurous nitrate, the precipitate of phosphate, vanadate, chromate, and carbonate was ignited in platinum, fused with a little sodium carbonate, leached with water, and filtered into a small graduated flask. After colorimetric determination of the chromium, sulphuric acid was added, both chromium and vanadium were reduced by sulphur dioxide gas, and the titration carried out as described.

TABLE III.—*Test determinations of vanadium added to rocks and ores in presence of chromium.*

No.	Chromic oxide.	Vanadium pentoxide.	Vanadium pentoxide.	
			Found.	Error.
	Mgs.	*Mgs.*	*Mgs.*	*Mg.*
[a]22	7	6.76	6.81	+0.05
			6.48	— .28
			6.43	— .33
			6.37	— .37
[a]23	3	3	3.08	+ .08
			3.13	+ .13
			3.03	+ .03
			3.08	+ .08
[b]24	1.6	1.87	1.86	— .01
			1.97	+ .10
			2.07	+ .20
			1.86	— .01

[a] Five grams iron ore.

[b] Two grams silicate.

These and other experiments show that by taking not over 5 grams of ore or rock, vanadium, if present to the extent of 0.01 or 0.02 per cent, can be readily estimated by exercising reasonable care in all the operations. Absolute confirmation of its presence can be easily obtained by evaporating and igniting the solution to remove excess of sulphuric acid, taking up with a few drops of dilute nitric acid, and adding to the solution in a test tube a drop or two of hydrogen peroxide. In this way positive or negative assurance as to the presence of vanadium is given when the result of titration alone might be uncertain. Addition of ether at the same time affords a simultaneous test for chromium by its blue color, and this might, perhaps, be made use of, if necessary, to remove all or the greater part of the chromium prior to titration of the vanadium, since the oxidation product of the latter does not dissolve in the ether.

It is even possible that the dark-brown color produced by hydrogen peroxide might be utilized for an exact colorimetric method for estimating vanadium.

DISTRIBUTION AND QUANTITATIVE OCCURRENCE OF VANADIUM AND MOLYBDENUM IN ROCKS OF THE UNITED STATES.

By W. F. HILLEBRAND.

Aside from its well-known mineral combinations, vanadium has long been known to occur in magnetites and other iron ores. Hayes in 1875 reported its occurrence in a great variety of rocks and ores. Quoting from Thorpe's Dictionary of Chemistry: "It is said to be diffused with titanium through all primitive granite rocks (Dieulafait) and has been found by Deville in bauxite, rutile, and many other minerals, and by Bechi and others in the ashes of plants and in argillaceous limestones, schists, and sands * * * ." It is further reported to comprise as V_2O_5 0.02–0.07 per cent of many French clays, 0.02–0.03 per cent of some basalts, 0.24 per cent of a coal of unknown origin and 0.45 per cent of one from Peru, amounting to 38.5 per cent and 38 per cent of the ash, and noted respectively by Mourlot and Torrico y Meca. Doubtless many other instances of its occurrence have been noted.

In Table I following is shown its quantitative occurrence and distribution in a large number and variety of igneous rocks of the United States arranged according to their silica contents; and in Table II the same data are given for a few of the component minerals separated from some of these rocks, while Table III shows its presence in metamorphosed and secondary rocks by a few examples of roofing slates and schists and especially by two composite samples representing 253 sandstone and 498 building limestones. These last two afford positive proof of its general distribution through rocks of those classes. Incidentally some information has been acquired as to molybdenum. Owing to lack of entire certainty as to its condition of oxidation, the vanadium is tabulated in terms of both V_2O_5 and V_2O_3, a point which will be reverted to later on. With very few exceptions the amount of each sample taken for analysis was 5 grams. The reagents used were carefully tested and found free from vanadium and molybdenum. Except Nos. 38, 39, 47, 52, and 53, by Dr. H. N. Stokes, all determinations are by myself.

TABLE I.—*Igneous rocks.*

No.	Name and locality of occurrence.	SiO_2.	$V_2O_5=V_2O_3$.		Mo.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1	Melilite-nepheline-basalt, Uvalde County, Tex.	38	0.054	0.045	
2	Nephelinite, Uvalde County, Tex	40	.042	.035	
3	Saxonite, Douglas County, Oreg	41.5	none	none	
4	Diorite, Cecil County, Md	44	.062	.052	none
5	Gabbro, Adirondack region, N. Y	45	.02	.017	
6	Plagioclase-basalt, Uvalde County, Tex	45	.048	.04	
7	Amphibole-gabbro, Alpine County, Cal	46	.046	.038	none
8	Plagioclase-gneiss, Amador County, Cal	46.5	.033	.027	
9	Diorite, Mitchell County, N. C	47	.05	.042	
10	Porphyry, La Plata County, Colo	47	*a*.06	*a*.05	
11	Amphibole-gabbro, Tuolumne County, Cal	47	.024	.02	none
12	Orthoclase-bearing basalt, Uvalde County, Tex	48?	.048	.04	
13	Orthoclase-bearing basalt, Uvalde County, Tex	48	.02	.017	
14	Norite, Cecil County, Md	48	.023	.019	
15	Gabbro, Union County, Tenn	48	.038	.032	
16	Gabbro, Douglas Island, Alaska	48	.055	.046	none
17	Nepheline-basanite, Colfax County, N. Mex	48.5	.044	.037	
18	Olivine-basalt, Kruzof Island, Alaska	49.5	.054	.045	none
19	Diabase, Mount Ascutney, Vt	49.5	.034	.028	
20	Phonolite, Cripple Creek, Colo	50	.033	.027	
21	Syenite-lamprophyre, Prowers County, Colo	50.5	.04	.033	
22	Augite-andesite-porphyry, Electric Peak, Wyo.	50.5	.045	.038	
23	Pyroxenic gneiss, Calaveras County, Cal	51.5	.10	.083	none
24	Labradorite-porphyrite, Michigamme iron district, Mich	52.5	.048	.04	
25	Pyroxenite, Cecil County, Md	53	.04	.034	none
26	Orendite, Sweetwater County, Wyo	54	.022	.018	
27	Andesite, El Paso County, Colo	54?	.018	.015	trace?
28	Nepheline-syenite, El Paso County, Colo	54.5	.022	.018	trace?
29	Diorite, Butte and Plumas counties, Cal	54.5	.037	.031	none
30	Quartz-diorite, Cecil County, Md	55	.043	.036	none
31	Diorite, La Plata County, Colo	55.5	.038	.032	
32	Camptonite? San Miguel County, Colo	55.5	(*b*)	(*b*)	
33	Phonolite, Colfax County, N. Mex	56	trace	trace	
34	Augite-bronzite-andesite, Unga Island, Alaska.	56.5	.046	.038	none
35	Andesite, El Paso County, Colo	57 ?	.025	.021	trace?
36	Spilosite, Michigamme iron district, Mich	58	.03	.025	none
37	Hornblende-granite, Cecil County, Md	58.5	.022	.018	none
38	Latite, Tintic district, Utah	60	.007	.006	none
39	Monzonite, Tintic district, Utah	60	.024	.02	trace
40	Diorite-porphyry La Plata Mountains, Colo	60.5	.02	.017	
41	Trachyte-andesite tuff, Tuolumne County, Cal	62.5	.017	.014	
42	Diorite, Douglas Island, Alaska	63	*a*.012	*a*.01	none
43	Rhyolite, San Miguel County, Colo	64.5	.004	.003	trace
44	Syenite, Mount Ascutney, Vt	65.5	trace?	trace?	
45	Quartz-mica-diorite, Tuolumne County, Cal	65.5	.013	.011	trace
46	Quartz-monzonite, Calaveras County, Cal	67	.014	.012	trace
47	Rhyolite, Tintic district, Utah	69	.009	.008	none
48	Quartz-diorite, Amador County, Cal	69.5	.005	.004	trace
49	Trachyte, Highland County, Va	69.5	trace?	trace?	
50	Biotite-granite, Amador County, Cal	70.5	trace	trace	trace
51	Rhyolite, Crater Lake, Oreg	71	.004	.003	ft. tr.
52	Monzonite (altered), Tintic district, Utah	71	.021	.017	none
53	Rhyolite (quartz-porphyry), Tintic district, Utah	71.5	.016	.013	none
54	Rock between rhyolite and dacite, Sutter County, Cal	71.5	trace	trace	
55	Syenite-porphyry, Mount Ascutney, Vt	73	none	none	
56	Granite-porphyry, Mount Ascutney, Vt	73.5	none	none	
57	Granite, Union County, Tenn	76.5	none	none	

a Approximate. *b* Lost, but considerable.

TABLE II.—*Component minerals from certain of the above igneous rocks.*

No.	Name and source.	SiO_2.	$V_2O_5 = V_2O_3$.		Mo.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
7^a	Amphibole from 7	(?)	0.075	0.062	none
11^a	Amphibole from 11	46	.044	.037	none
21^a	Pyroxene from 21	51.5	.043	.036	
23^a	Biotite from 23	36.5	.153	.127	none
29^a	Amphibole from 29	50	.08	.066	
45^a	Biotite from 45	(?)	.057	.048	none
46^a	Biotite from 46	35.5	.08	.066	

TABLE III.—*Miscellaneous.*

No.	Name and locality of occurrence.	SiO_2.	$V_2O_5 = V_2O_3$.		Mo.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
58	Epidotic schist, Mitchell County, N. C	48	0.057	0.047	
59	Quartz-schist, Madera County, Cal	79	trace	trace	
60	Serpentine, Connecticut Valley, Mass	38.5	none	none	
61	Sea-green roofing slate, West Pawlet, Vt	68	.017	.017	
62	Two red roofing slates (equal parts), Washington County, N. Y	67 56	.008	.007	
63	253 sandstones	78.5	.003	.003	
64	498 building limestones	14	.004	.004	

Of the igneous rocks specimens were so selected as to represent not only many widely separated localities, but also numerous varieties from the least siliceous up to those high in silica, in order to ascertain whether a preconceived opinion that the vanadium accompanied chiefly the less siliceous rocks was well founded or not. The choice was, however, confined largely to those rocks analyzed in this laboratory within the past three or four years of which a supply of powder remained after the original analyses had been completed, and hence the list is perhaps not fully representative. Nevertheless it permits of drawing certain conclusions, the chief of which is that the vanadium predominates in the less siliceous igneous rocks and is absent, or nearly so, in those high in silica. The inference, based on the existence of the mineral roscoelite, classed as a vanadium mica, at once suggests itself, that the ultimate source of the vanadium may be one or more of the heavier silicates such as the biotites, pyroxenes, and amphiboles, and a few tests on all the available mineral separation products lend strong support to this view. For instance, the amphibole-gabbros 7 and 11 show 0.038 per cent and 0.02 per cent V_2O_3, while the amphiboles 7^a and 11^a separated from them give 0.062 per cent and 0.037 per cent; the pyroxenic gneiss 23 shows 0.083 per cent against 0.127 from its contained biotite 23^a; the diorite 29 with 0.031 per cent contains an amphibole 29^a with 0.066 per cent; from 0.011 per cent in the quartz-mica-diorite 45 and 0.012 per cent in the quartz-monzonite 46 the percentages *rise to 0.048* and 0.066 in their separated biotites 45^a and 46^a. The pyroxene 21^a shows, however, practically the same amount as its mother rock, the syenite-lamprophyre 21.

In most of these cases, notably the last one, the vanadium in the separated mineral is not sufficiently in excess of that in the rock from which it was taken to account for all of that found in the latter. Hence, if the determinations are correct it must also be a constituent of some other mineral than the one analyzed. In roscoelite the trivalent condition of vanadium corresponding to the oxide V_2O_3 is now recognized as probable, although Roscoe's analysis reports V_2O_5 and Genth's an oxide intermediate between V_2O_3 and V_2O_5. This assumption seems to be necessary if the mineral is to be regarded as a mica, and it is then doubtless the equivalent of trivalent iron or aluminum. It would then be natural to look for it in the aluminous or ferric silicates of igneous rocks, certain biotites, pyroxenes, and hornblendes, and its absence in such minerals as serpentine and chrysolite, as shown by analyses 3 and 60, appears natural enough.

Few and inconclusive as the above comparisons are, they seem to favor strongly this view as to the source of the vanadium, and in a measure are confirmatory of the observation of Hayes (Proc. Am. Acad. Arts Sci., Vol. X, 1875, p. 294), who rather indefinitely associates it with phosphorus and proto-salts of iron and manganese, which are usually more prominent components of basic than of acid rocks.

We are probably justified by the evidence in tabulating the vanadium as V_2O_3 in analyses of igneous and some metamorphic rocks which have undergone little or no oxidation, but with sandstones, clays, limestones, etc., which are of more or less decided secondary origin, this is probably not the case. The probabilities are there largely in favor of its acid character and the existence of various vanadates of calcium, iron, aluminum, etc., in which case it should appear in analytical tables as V_2O_5.[1]

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[1] In the regular course of analysis vanadium will be weighed with alumina, iron, titanium, etc., since it is precipitated by both ammonia and sodium acetate in presence of those and other metals, hence the alumina percentages in nearly all rock analyses heretofore made are subject to correction for the vanadium the rock may have held. This correction is of course to be made in terms of V_2O_5 and not of V_2O_3.

All determinations of iron are likewise affected by its presence, whether as V_2O_5 or V_2O_3. As V_2O_3 it will make the FeO appear too high in the proportion V_2O_3 : 4FeO, or 150.8:288, an error which becomes appreciable in some of the basic rocks and amounts to 0.25 per cent in the biotite 23^a. As V_2O_5 the FeO will not be affected, but in either condition the Fe_2O_3 will need correction and to a different extent, according as the titration of iron is made after reduction by hydrogen sulphide or by hydrogen. If the former is used, as should always be the case in presence of titanium, the vanadium is reduced by it to V_2O_4, which in its action on permanganate is equivalent to 2 molecules of FeO representing 1 of Fe_2O_3, or only one-half as great as the influence on the FeO titration of the same vanadium as V_2O_3. An example will make this clear:

Found 2.50 per cent apparent FeO in a rock containing 0.13 per cent V_2O_3.
Deduct 0.25 per cent FeO, equivalent in its action on $KMnO_4$ to 0.13 per cent V_2O_3.
Leaving 2.25 per cent FeO corrected.
Found 5 per cent apparent total iron as Fe_2O_3 in the same rock.
Deduct 0.14 per cent Fe_2O_3, corresponding to 0.13 per cent V_2O_3.
Leaving 4.86 per cent corrected total iron as Fe_2O_3.
Deduct 2.50 per cent Fe_2O_3, equivalent to 2.25 per cent FeO.
Leaving 2.36 per cent Fe_2O_3 in the rock.

Failure to correct for the vanadium in both cases would have made the figures for FeO and Fe_2O_3, *respectively, 2.50* and 2.22 instead of 2.25 and 2.36 as shown above.

It was not until the greater part of the above tests had been finished that any careful attempt was made to identify molybdenum as well as vanadium. From the evidence gathered during the latter part of the work it would seem that molybdenum, when it does occur, is a much less important constituent quantitatively than vanadium, and that unlike the latter it accompanies the more acid rocks. Molybdenite is a well-known accessory constituent of some granites, etc., but in the above instances its amount was extremely small and no hint was obtained as to its state of combination.

CHEMICAL METHOD EMPLOYED.

In conclusion it is proper to outline the method by which the foregoing tests were carried out, and to indicate the precautions that must be observed in order to insure good results.

Quite a number of workers have busied themselves with the problem of vanadium estimation in ores and rocks, particularly magnetites and other iron ores, and the methods used have been often diverse in parts if not altogether. There is nothing absolutely novel in the following except that chromium and vanadium when together need not be separated, but are determined, the former colorimetrically, the latter volumetrically, in the same solution as detailed elsewhere (p. 44).

Five grams of the rock are thoroughly fused over the blast with 20 of sodium carbonate and 3 of sodium nitrate. After extracting with water and reducing manganese with alcohol it is probably quite unnecessary, if the fusion has been thorough, to remelt the residue as above, though for magnetites and other ores containing larger amounts of vanadium than any of these rocks, this may be necessary, as Edo Claassen has shown.[1] The aqueous extract is next nearly neutralized by nitric acid, the amount to be used having been conveniently ascertained by a blank test with exactly 20 grams of sodium carbonate, etc., and the solution is evaporated to approximate dryness. Care should be taken to avoid overrunning neutrality because of the reducing action of the nitrous acid set free from the nitrite, but when chromium is present it has been my experience that some of this will invariably be retained by the precipitated silica and alumina, though only in one case have I observed a retention of vanadium, it being then large. The use of ammonium nitrate instead of nitric acid for converting the sodium carbonate into nitrate did not seem to lessen the amount of chromium retained by the silica and alumina.

As a precautionary measure, therefore, and always when chromium was to be estimated also, the silica and alumina precipitate was evaporated with hydrofluoric and sulphuric acids, the residue fused with a little sodium carbonate and the aqueous extract again nearly neutral-

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[1] Am. Chem. Jour., Vol. VIII, p. 437.

ized with nitric acid and boiled for a few moments, the filtrate being added to the main one.

Mercurous nitrate was now added to the alkaline solution in some quantity so as to obtain a precipitate of considerable bulk containing chromium, vanadium, molybdenum, tungsten, phosphorus, and arsenic, should all happen to be in the rock, and also an excess of mercurous carbonate to take up any acidity resulting from the decomposition of the mercurous nitrate. Precipitating in a slightly alkaline instead of a neutral solution renders the addition of precipitated mercuric oxide unnecessary for correcting this acidity. If the alkalinity, as shown by the formation of an unduly large precipitate, should have been too great, it may be reduced by careful addition of nitric acid until an added drop of mercurous nitrate no longer produces a cloud.

After heating and filtering, the precipitate is ignited in a platinum crucible after drying and removing from the paper to obviate any chance of loss of molybdenum and of injury to the crucible by reduction of phosphorus or arsenic. The residue is fused with a very little sodium carbonate, leached with water, and the solution, if colored yellow, filtered into a graduated flask of 25 cubic centimeters or more capacity. The chromium is then estimated accurately in a few minutes by comparing with a standard alkaline solution of potassium monochromate (p. 37). Then, or earlier in absence of chromium, sulphuric acid is added in slight excess and molybdenum and arsenic together with occasional traces of platinum are precipitated by hydrogen sulphide, preferably in a small pressure bottle.[1] If the color of the precipitate indicates absence of arsenic, the filter with its contents is carefully ignited in porcelain and the delicate sulphuric acid test for molybdenum is applied.

The filtrate, in bulk from 25 to 100 cubic centimeters, is boiled in a current of carbon dioxide to expel hydrogen sulphide, and titrated at a temperature of 70–80° C. with a very dilute solution of permanganate representing about one milligram of V_2O_5 per cubic centimeter as calculated from the iron strength of the permanganate, one molecule of V_2O_5 being indicated for each one of Fe_2O_3. One or two checks are always to be made by reducing again in a current of sulphur dioxide gas, boiling this out in a current of carbon dioxide again, and repeating the titration.

As shown in a previous paper (p. 45), the presence of even thirty times as much Cr_2O_3 as V_2O_5 does not prevent a satisfactory determination of the vanadium if the precautions therein given are observed, provided there is present not less than one-half to 1 milligram of V_2O_5 in absolute amount. In absence of chromium less than half a milligram can be readily estimated. The phosphoric acid almost invariably present does not affect the result.

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[1] From a sulphuric solution the separation of molybdenum by hydrogen sulphide is much more rapid and satisfactory than from a hydrochloric solution.

In case the volume of permanganate used is so small as to make doubtful the presence of vanadium, it is necessary to apply a qualitative test which is best made as follows: The solution is evaporated and heated to expel excess of sulphuric acid, the residue is taken up with 2 or 3 cubic centimeters of water and a drop or two of dilute nitric acid, and a couple of drops of hydrogen peroxide are added. A characteristic brownish tint indicates vanadium. Unless the greater part of the free sulphuric acid has been removed the appearance of this color is sometimes not immediate and pronounced, hence the above precaution.

The above is a surer test to apply than the following: Reduce the bulk to about 10 cubic centimeters, add ammonia in excess and introduce hydrogen sulphide to saturation. The beautiful cherry-red color of vanadium in ammonium sulphide solution is much more intense than that caused by hydrogen peroxide in acid solution, but the action of ammonia is to precipitate part or all of the vanadium with the chromium or aluminum that may be present or with the manganese used in titrating, and ammonium sulphide is unable to extract the vanadium wholly from these combinations. Usually, however, the solution will show some coloration, and addition of an acid precipitates brown vanadium sulphide, which can be collected, ignited, and further tested if desired.

SUMMARY OF RESULTS.

Vanadium occurs in quite appreciable amounts in the more basic igneous and metamorphic rocks, up to 0.08 per cent or more of V_2O_3, but seems to be absent or nearly so from the highly siliceous ones. The limited evidence thus far obtained points to the heavy ferric-aluminous silicates as its source—the biotites, pyroxenes, amphiboles. As opportunities offer further evidence will be accumulated and it is hoped that other chemists will lend their aid.

Limestones and sandstones appear to contain very small amounts of vanadium, as shown by analyses of a composite sample of each, aggregating over 700 different occurrences.

From the few tests of molybdenum it appears as if this element were confined to the more siliceous rocks. It is present in no observed case in amount sufficient for quantitative measurement when operating on 5 grams of material.

NOTE.—Since the above was written a few tests have been made on minerals of which powdered samples were at hand. A phlogopite from Burgess, Canada, gave 0.007 per cent V_2O_3. Mica from Laurel Hill, Georgia, gave 0.026 per cent V_2O_3. Protovermiculite from Magnet Cove, Arkansas, gave 0.04 per cent V_2O_3. Hallite from Chester County, Pennsylvania, gave 0.01 per cent V_2O_3. Jeffersonite from Franklin Furnace, New Jersey, gave none, and a nonferruginous amphibole from St. Lawrence County, New York, gave a faint trace.

WARNING AGAINST THE USE OF FLUORIFEROUS HYDROGEN PEROXIDE IN ESTIMATING TITANIUM.

By W. F. HILLEBRAND.

Dunnington[1] has pointed out a source of error to be guarded against in estimating titanium in rocks and minerals by Weller's method, due, as he believes, to the partial reversion, in certain cases, of ordinary titanic to meta-titanic acid, which does not afford a yellow color with hydrogen peroxide. It remains for me to indicate another source of error in the possible presence of fluorine in the hydrogen peroxide.

For two years the colorimetric method has given reasonable satisfaction in this laboratory, but recently a new lot of hydrogen peroxide was purchased of a different brand from that hitherto used, and after a time it was noticed that the results obtained were in some instances far too high, and that no two determinations agreed.

It is known that hydrogen peroxide does not produce a yellow color in titanium solutions carrying hydrofluoric acid or fluorides, and moreover the addition of even a drop of the dilute acid to an already peroxidized titanium solution weakens the color. For this reason it is necessary to take the greatest care to insure the complete expulsion of all fluorine when dissolving rocks or minerals by means of hydrofluoric and sulphuric acids prior to the colorimetric estimation. A drop of hydrofluosilicic acid acts similarly, but the latter reagent can not be made to completely discharge the color even if added in great excess.

This, however, was not suspected as the cause of our trouble until, on referring to the circular of one of the leading makers of hydrogen peroxide in this country, whose product has always given satisfactory results in titanium work, it was found that among the various acids enumerated as usually to be found in the commercial article, hydrofluroic acid appears. Talbot and Moody, in the Technology Quarterly, v. 123, mention hydrofluosilicic acid as of frequent occurrence in the peroxide manufactured a few years ago. On examining the suspected peroxide by neutralizing with fixed alkali, evaporating to dryness, and heating with strong sulphuric acid, fluorine was detected by the odor of the acid evolved and by its action on glass.

It is therefore imperative to use only hydrogen peroxide which is free from fluorine in estimating titanium, for its presence may utterly vitiate the results, even if only 2 or 3 cubic centimeters of the peroxide are employed.

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[1] *Jour. Am. Chem. Soc.*, Vol. XIII, p. 210.

MINERALOGICAL NOTES.

By W. F. Hillebrand.

1. Calaverite from Cripple Creek, Colorado.

The occurrence of tellurium in the ores of the mining district of Cripple Creek, Colorado, has been known from an early day in the as yet brief industrial history of that region. That it was, in part at least, associated with gold was likewise known from the observance of a crystallized gold-tellurium mineral. Although the ores of the district are chiefly gold carriers, they contain also a little silver, and since recognized silver minerals had not been observed, or at most only in minute amount, it seemed probable that the silver was associated with the gold in the tellurium compound. Indeed, Mr. R. Pearce, of Denver, came to the conclusion, from analyses of oxidized and unoxidized ores,[1] that this mineral was sylvanite, and he says: "Sylvanite itself appeared in little silver white specks disseminated through a mass of greenish rhyolite." Notwithstanding that F. C. Knight[2] has identified calaverite by analysis and that sylvanite has not been identified by positive chemical and crystallographical tests, the evidence of Mr. Pearce as to its presence, in some portions of the district at least, is entitled to consideration.

The telluride examined by me was collected by R. A. F. Penrose, jr., who procured his material from three different mines in order to ascertain whether it was of constant or varying composition, or, in fact, whether there might not be more than one specific compound. That the composition does vary within narrow limits the analyses show; but there is no reason apparent for assuming the existence of more than one species in the ores of these particular mines.

The material from the Prince Albert mine, the first received, was with little trouble brought into an almost ideal condition of purity. It was in part apparently fairly well crystallized, but the measurements made by Prof. S. L. Penfield, of New Haven, are unfortunately not decisive as to the system of crystallization, as shown by his notes at the close of this paper. The specific gravity of this material was 8.91 at 24° C., which becomes 9 when corrected for a small admixture of silico-ferruginous gangue of assumed specific gravity 2.70 (probably

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[1] Proc. Colorado Sci. Soc., Vol. V, 1894, pp. 5, 11.

[2] Ibid., Vol. V, 1894, p. 70.

low). The other samples were imperfectly crystallized and held too much foreign matter of uncertain composition to make specific gravity determinations of any value.

	I. Prince Albert mine.	II. Raven mine.	III. C. O. D. mine.
Tellurium (Te)	57.27	47.69	53.89
Gold (Au)	38.95	33.93	39.31
Silver (Ag)	3.21	1.47	.85
Insoluble	.33	5.80	.91
Ferric oxide (Fe_2O_3)	[a].12		
Iron (Fe)		5.41	1.67
Sulphur (S)		[b]6.17	1.58 (2.96 FeS_2)
Manganese (Mn)			[c].23
Calcium (Ca)			.51
Magnesium (Mg)			.10
Oxygen, fluorine, and soluble silica by difference			[d].95
	99.88	100.47	100.00

[a] This was included with the insoluble matter in arriving at the corrected density.
[b] Calculated from the Fe to make FeS_2.
[c] As MnO_2?
[d] A part of the calcium found in solution was derived from fluorite, which likewise constituted some of the insoluble matter in this instance.

Selenium has been reported in the oxidized ores of the district,[1] but it could not be detected in the amount of mineral taken for the above analyses.

Excluding everything but gold, silver, and tellurium and recalculating to 100, the following comparison is obtained:

	I.		II.		III.	
	Per cent.	Ratio.	Per cent.	Ratio.	Per cent.	Ratio.
Te	57.60	2.01	57.40	2.05	57.30	2.09
Au	39.17	1.00	40.83	1.00	41.80	1.00
Ag	3.23		1.77		.90	
	100.00		100.00		100.00	

The ratio here obtaining is that for sylvanite and calaverite, but the very low percentage of silver shows that the mineral is calaverite. Indeed the first analysis agrees almost exactly with Genth's analyses

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[1] F. C. Knight, Proc. Colorado Sci. Soc., Vol. V, 1894, p. 68.

of the species. Interesting is the slight variation in the ratio between gold and silver, and the very low percentage of silver in the mineral from the C. O. D. and Raven mines. Calaverite, the lowest silver carrier of the gold-silver tellurides, has not heretofore been known to carry less than 3 per cent of silver.

The pyrognostic characteristics of the mineral from the Prince Albert mine were essentially those ascribed to calaverite. In the closed tube it fuses, giving a white coating near the assay, and a globular gray coating just above, which latter by strong heat can be in part driven higher up, leaving the glass covered with the same white fused coating as lower down. This latter is yellow while hot. On charcoal the mineral fuses with a green flame, giving a white coating and similar fumes, and leaving a yellow bead. The color is pale bronze-yellow, in powder greenish gray. The hardness is not less than and perhaps a little over 3. Specific gravity, as given above, 9.

The identity of the telluride occurring at Cripple Creek, which in oxidizing gives free gold and oxidized tellurium compounds,[1] seems thus satisfactorily established, but unless there is another richer in silver, as believed by Pearce, the mode of occurrence of the silver in some of the ores is still in large part unaccounted for. It may be derived from a very rich argentiferous tetrahedrite of which Professor Penrose submitted a small specimen for identification. This carries over 11 per cent of silver, but is said to be excessively scarce and therefore hardly to be considered in this connection, unless indeed this should have been the original source of most of the silver and later have suffered oxidation to a great extent whereby the silver has become more evenly distributed throughout the ore.

Professor Penfield has kindly contributed the following notes on the crystallography of the mineral:

> The crystals of calaverite which were examined were developed with prismatic habit, but the prismatic zone was striated to such an extent that it was impossible to identify a single face in the zone, and on the reflecting goniometer almost an unbroken band of signals was obtained in a revolution of 360°. Owing to oscillatory combinations the crystals were also much distorted, so that they did not present regular cross sections.
>
> The prisms were attached so that doubly terminated ones were not observed, while the faces at the free end were small and developed with so little symmetry that after a study of a number of crystals it was found impossible to determine with certainty the system of crystallization.
>
> The crystals do not exhibit the perfect cleavage ascribed to sylvanite and krennerite, but are similar to the former in some of their angles. When placed in position to show their relation to sylvanite they have their prismatic development parallel to the *b* axis. One crystal, which owing to its development was more carefully measured than any of the others, was apparently a twin about 101, and showed

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[1] From tests made by myself on a number of specimens collected by Professor Penrose the combination seems to be chiefly if not altogether with iron, but whether as tellurite or tellurate could not be ascertained. Knight (loc. cit., p. 69), however, has shown that the combination, in some cases at least, is a tellurite, approximating to the formula $2(Fe_2O_3, 2TeO_2)+H_2O$.

at the end the forms 111 and 110. The measurements compared with the corresponding ones of sylvanite are as follows:

		Sylvanite.
111∧(111) over twinning plane	93° 35′	94° 30′
110∧(110) over twinning plane	35 2	34 43
110∧111	36 35	37 3
110∧111 in twin crystal	36 33	37 3

Other forms which were measured could not be referred to the sylvanite axes, and it seems probable from their development and lack of symmetry that the crystals are triclinic; but no satisfaction was obtained after a long and careful study of the limited supply of material on hand.

In conclusion therefore it may be stated that the crystals are probably triclinic, but near sylvanite in angles and axial ratio.

NOTE.—Since the foregoing work was completed additional analyses of Cripple Creek tellurides have been made by Profs. A. H. Chester[1] and W. H. Hobbs.[2] From the crystallographic data they were able to obtain it would appear that neither of the minerals examined by them can be identical with calaverite, though both possess the same general formula MTe_2, in which, however, the ratio of gold to silver was not at all alike. The analysis of that one, which by its crystallographic features was identified as krennerite, has even less silver than the specimens of calaverite from the C. O. D. mine, while goldschmidtite, showing crystallographic relations with sylvanite, contains 8.95 per cent Ag to only 31.41 per cent Au, thus supporting, in a measure, Mr. Pearce's belief in the existence at Cripple Creek of a telluride much richer in silver than calaverite.

2. TELLURIDES FROM CALIFORNIA.

In a suite of tellurides from the Mother Lode region in California, collected by Mr. F. L. Ransome, of the United States Geological Survey, I have been able to identify a nickel telluride (melonite?), a mercury telluride (coloradoite?), besides petzite and hessite.

MELONITE?.

Several specimens from the old Stanislaus mine,[3] the original source of Genth's melonite[4] (Ni_2Te_3?), but now included with the Melones and

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[1] On krennerite from Cripple Creek, Colorado. Am. Jour. Sci., 4th series, Vol. V, 1898, p. 375.

[2] Goldschmidtite, a new mineral. Am. Jour. Sci., 4th series, Vol. VII, 1899, p. 357.

[3] Mr. Ransome has kindly furnished the following notes: This mine is situated on the south slope of Carson Hill, Calaveras County, just above Robinsons Ferry, and has not been worked for several years. There is no prominent vein at this point, the ore being very irregularly distributed, and occurring in small, nearly horizontal, stringers in dark clay slates of Carboniferous age, with nearly vertical dip. This mine has long been known as a source of interesting tellurides, and Dana, in the sixth edition of his System of Mineralogy, cites petzite, calaverite, melonite, and altaite as occurring here. The other ore minerals are pyrite and galena, the latter in small quantities. The ore-bearing stringers are filled with quartz, or a mixture of quartz and calcite as a gangue. The rich masses of tellurides appear, however, to be usually associated with calcite (or dolomite). The melonite of specimen No. 16, shows at least one perfect cleavage, resembling in the thinness of the resulting laminæ the cleavage of the micas. The cleavage faces are usually somewhat curved, and possess a splendent metallic luster. The cleavage can best be detected by carefully scraping thin folia from such a brilliant surface with a sharp knife point. The color of the cleavage faces is pale bronze yellow.

[4] *Long o,* accented (mel-ǫ-nite).

other claims under the name Melones mine, showed plainly a nickel telluride of reddish-white cast, of color like that of bismuth,[1] thickly scattered in grains, and showing pronounced cleavage and a brilliant luster. A concentrate was prepared by the aid of cadmium-boro-tungstate solution, and this was then laboriously hand picked by the aid of a powerful glass. There was certainly more than one foreign mineral present, but identification was not possible except as to a little gold and petzite. The chief impurity was a silver mineral, presumably hessite. If so, the analyses seem to indicate also native tellurium. A perfectly pure article could not be extracted because of difficulty in sometimes distinguishing the foreign minerals from the one sought, but it was hoped that an analysis of both the selected and rejected portions would permit of calculating the composition of the nickel mineral with considerable certainty on the reasonable assumption that no impurity had been removed in relative excess over the other or others.

The analyses below represent the composition of (*a*) the rejected, (*b*) the original, and (*c*) the selected material. Analysis *b* is given chiefly because of the cobalt determination, the nickel being probably a little high. Although but 0.22 and 0.13 grams, respectively, were available for the analyses *a* and *c* the data are believed to be more trustworthy on the whole than those of *b*, hence the figures under *d* have been obtained by calculation based on *c* and *a* only, after reducing them to 100. Under *e* is shown the theoretical composition of $NiTe_2$. Small amounts of iron, traces of copper, and perhaps one or two other elements are omitted, besides the three-fourths to 2 per cent of gold and petzite that remained unattacked by cold dilute nitric acid, in which the nickel mineral is readily soluble.

The specific gravity of *b* at 22.5 was 7.72, which is probably higher than the true density of the pure nickel telluride.

Analyses of melonite.

	a	*b*	*c*	*d*	*e* $NiTe_2$.
Te	75.29	77.72	80.75	81.40	81.29
Ni	15.71	17.16	18.31	18.60	18.71
Co		.10			
Ag	8.44	5.09	.86	....	....
	99.44	100.07	99.92	100.00	100.00

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[1] Under a lens, and to the unaided eye in certain lights, the color appears more bronze yellow.

If hessite and native tellurium constitute the foreign admixture the mineralogical composition of *a* and *c* is shown to be as follows:

	a	*c*
$NiTe_2$	84.44	97.89
Hessite	13.51	1.38
Tellurium	2.05	.73
	100.00	100.00

There is here indicated a considerable selective separation of the foreign minerals, since the relative proportions of tellurium and hessite are very different in the two mixtures, but the amounts operated on were so small that a very slight actual error in a determination might give rise to this change in the relative proportions of impurities without affecting materially the ratios found for the components of the nickel telluride. The three analyses taken together point unmistakably to $NiTe_2$ as the formula for the latter mineral. The question then arises, Is this Genth's melonite, or is it a new mineral? Genth found:

Te	73.43
Ni	20.98
Ag	4.08
Pb	.72
	99.21

from which, after deducting hessite, altaite, and free tellurium, he deduces the formula Ni_2Te_3, requiring Te 76.49 and Ni 23 51.

The difference between his and my own analyses is too great to admit of bringing them into accordance, yet I am indisposed to believe that two minerals are represented, for both occurrence and appearance are opposed to such a view. The present mineral is from the same source as Genth's. Its physical characteristics, so far as ascertainable, coincide with those of melonite, and it is called melonite by the people at the mine. Melonite was considered by Genth to be hexagonal on the strength of its eminent cleavage and the observation of a single microscopic 6-sided plate. Mineralogically a hexagonal form in the pyrite group, assuming this mineral to belong there, is not to be looked for, but the evidence in favor of hexagonal crystallization is too meager to permit this to be used as an argument one way or another.

COLORADOITE?

One small specimen from the Norwegian mine showed in dolomite, petzite, hessite, and a mercury telluride. Superficially the latter was not to be distinguished from the accompanying petzite and hessite, and it was in insufficient amount to admit of analysis for the determination of its formula. It however gave the tests noted by Genth for the original coloradoite from Colorado, and in addition the following characteristic may be noted: On heating with strong nitric acid it becomes coated with a white insoluble salt of mercury, which retards further action of the acid.

It is, in all probability, coloradoite, and if so this is its second known locality of occurrence, though I have been informed that a mercury telluride has recently been found in western Australia.

PETZITE.

One specimen of petzite from the Norwegian mine gave such an abundance of pure material that an analysis seemed desirable. The results were as follows:

Au	25.16	1.98	1.00
Ag	41.87		3.04
Te	33.21	1.00	
Se	trace		
Mo	.08		
	100.32		

Approximate specific gravity at 23° C., 8.925. The molybdenum may exist as sulphide. The ratios lead almost exactly to the formula Au_2Te, 3 Ag_2Te.

3. HESSITE FROM MEXICO.

As an addition to the foregoing work may be given an analysis of hessite from a new locality—San Sebastian, Jalisco, Mexico—the material having been received from Mr. Frederic Chisolm:

Ag	61.16
Te	36.11
Pb	1.90
S. Fe. Zn	[a].83
	100.00
Specific gravity at 26° C	8.24

[a] Difference.

4. COVELLITE AND ENARGITE FROM MONTANA.

The only important occurrence of covellite in this country is at Butte, Montana, where it occurs in splendid indigo-blue masses. Specimens from the East Greyrock mine, collected by Mr. George W. Tower, formerly of the United States Geological Survey, gave almost the theoretical composition as shown below. Specific gravity at 26° C., 4.76, uncorrected for impurities.

An analysis of enargite collected by Mr. Tower in the Rarus mine, at Butte, is also given.

Analysis of covellite.

Cu	66.06
S	33.87
Fe	.14 = .30 FeS_2
Insol	.11
	100.18

Ratio Cu : S as 1 : 1.01.

Analysis of enargite.

Cu	48.67
Fe	.33
Zn	.10
As	17.91
Sb	1.76
S	31.44
Insol	.11
	100.32

5. TYSONITE AND BASTNÄSITE.

These minerals formed a single fine specimen half as large as the fist, without crystal faces, from Cheyenne Mountain, near Pikes Peak, Colorado. The bastnäsite covered one side of the tysonite to the depth of an inch. The line of demarcation between the two minerals was sharp, but examination of their sections by Mr. H. W. Turner showed the tysonite to be permeated by stringers of bastnäsite along numerous cracks and that occasional grains of the latter were embedded in the tysonite, which accounts for the CO_2 shown in the tysonite analysis. Attached to the tysonite at portions of its surface were other white and brownish alteration products derived from it, as shown by qualitative tests. The tysonite was evidently the remnant of a single large crystal, since, according to Mr. Turner, all parts had the same optical orientation. Mr. Turner further found the optical properties of both minerals, so far as determinable, to agree with those given in Dana's Mineralogy, and the index of refraction of the bastnäsite to be greater than that of the tysonite. He likewise noted in both minerals minute colored inclusions, indeterminable and very trifling in amount, and also in the tysonite "numerous minute angular cavities in which there is a liquid, often with gas bubble. Minute, clear, cuboidal crystals, apparently isometric, were also noted in some of these cavities."

The composition of the minerals was found to be as given by Allen and Comstock, with the exception that the ratios of cerium oxide to the oxides of the lanthanum group are not quite the same. The formulæ are not thereby affected.

Cerium was separated from the lanthanum group oxides by two precipitations by potassium hydroxide followed by long introduction of chlorine. After recovery of the earths remaining in solution, they were again subjected to this treatment to be certain of having all the cerium. In one case a small portion was thus recovered. The cerium was most carefully examined for thorium and traces of what appeared to be thoria were found. The other earths were wholly precipitable by potassium sulphate with exception of traces of what may be oxides of the yttrium group. Approximate molecular weight determinations of the combined oxides of these two groups were made, and they show an appreciable difference, which may, however, be due to the uncertainty of the method. It may be mentioned that on ignition of the sulphates of these earths they acted like the old didymium in that they lost exactly two-thirds of their SO_3 on ignition over the full flame of the Bunsen burner, a fact which would seem to exclude the presence of lanthanum. Their solutions were pink and gave pronounced absorption spectra. The ignited oxides freed from cerium were a dull, dirty brown, which became nearly white on blasting and acquired a distinct bluish cast on ignition in hydrogen. No appreciable reduction in weight followed heating in hydrogen. The material saved is at the disposal of anyone desiring to examine these earths spectroscopically.

Owing to the great difficulty in effecting complete decomposition of the minerals by sulphuric acid at a single treatment, the fluorine was obtained in condition for estimation by fusing with potassium carbonate after mixing with silica in the proportion of 0.6 gram mineral to 1 gram silica.

Fragments of tysonite when held in the blast gave a distinct crimson flame showing the lithium red line, but an alkali determination failed to reveal more than a trace of this element.

Of the bastnäsite very little pure material could be separated, and it was therefore impossible to place with certainty all the loss shown by the analysis, but a portion of it is to be charged to the oxides of the lanthanum group because of an accident.

Specific gravity of the bastnäsite 5.12 at 27° C. and of the tysonite 6.10 at 28° C., which becomes 6.14 when corrected for 2.65 per cent of bastnäsite.

Analysis of tysonite.

Ce_2O_3	[a] 42.89
La group	[b] 39.31
F	[c] 28.71
CO_2	.53
CaO	.18
Fe_2O_3	.11
Na_2O (with traces K_2O and Li_2O)	[d] .30
	112.03
Less O for F	12.08
	99.95

[a] 0.18 per cent ThO_2?
[b] At. w. 139.7; includes 0.21 per cent soluble in K_2SO_4.
[c] Mean of 28.86 and 28.56.
[d] Approximate.

Analysis of bastnäsite.

Ce_2O_3	[a] 37.71
La group (slight loss)	[b] 36.29
F	7.83
CO_2	[c] 20.03
Fe_2O_3	.22
Na_2O (with traces K_2O and Li_2O)	.18
H_2O	.08
	102.34
Less O for F	3.30
	99.04

[a] Mean of 37.73 and 37.69; includes .10 per cent ThO_2?
[b] At. w. 141; includes .09 per cent soluble in K_2SO_4.
[c] Mean of 19.94 and 20.11.

Neglecting the last three constituents in each case, the ratios become for

Bastnäsite .... $R : F, CO_3 = 1 : 2.94$
Tysonite .... $R : F, CO_3 = 1 : 3.05$

which ratio for tysonite is not changed by allowing for admixed bastnäsite.

The above direct fluorine determinations fully establish the hitherto assumed formulas $R''' F_3'$ for tysonite and $R''' (F' CO_3'')$ for bastnäsite.

6. PROSOPITE.

Early in 1896 Mr. George F. Kunz sent for examination a beautiful pale green mineral from Utah, supposed to be identical with the green variscite called by him utahlite in Mineral Resources of the United States, 1894, page 602. Under a recent date Mr. Kunz writes that Mr. T. H. Beck, of Provo, Utah, found the mineral "in 1895, in the Dugway mining district, Tooele County. It was found in a low range of hills about 5 miles long, surrounded by a desert on an arid region occurring as flat rock, associated with fluorite, native silver, slate, and trachytic rock (?), containing decomposed pyrite in which there was present a little free gold."

Unexpectedly this was found to be the hydrous aluminum-calcium fluoride prosopite, mixed with some quartz and probably fluorite, and colored by a small amount of some copper salt. A new and interesting occurrence for this very rare mineral is thus afforded.

The material as prepared for analysis after separation by a heavy solution proved to be still far from pure; quartz grains in amount from 1 to 2 per cent were left undissolved after complete conversion of the fluorides into sulphates, and presumably considerably more had been removed by the escaping fluorine. The total amount of quartz was not determined, and the material at hand did not suffice for attempts at more complete purification, so that the conclusions drawn from the analysis, while extremely probable, are not to be taken as altogether proven.

The specific gravity of the mineral as analyzed was 2.87 at 21° C. and the hardness about 4.5, both agreeing with the constants for prosopite. Furthermore, but little of the water (1.25 per cent) was expelled by several hours heating at 280° C. Analysis gave:

Al	20.08
Ca	17.55
Mg	trace
K	.12
Na	.32
Cu	.17
F	28.00
H_2O	14.24
Quartz and oxygen	19.52
	100.00

Neglecting copper, alkalies, and the oxygen calculated for their oxides, and assuming the water to exist entirely as hydroxyl, the following not very satisfactory atomic ratios result:

Al	.7407	2
Ca	.4380	1.18
F	1.4690	8.23
Hydroxyl	1.5808	

which become

Al	.7407	2
Ca	.3712	1
F	1.3354	7.87
Hydroxyl	1.5808	

if enough calcium and its equivalent in fluorine are subtracted to make the ratio Al : Ca exactly 2 : 1, on the not improbable assumption that fluorite is present as an admixture, an assumption that had to be made also for the Colorado prosopite in order to bring it into close agreement with Brandl's formula.

There is now a deficiency in the acidic radicals. The figures for Al, Ca, and H_2O are undoubtedly very nearly correct, while the fluorine may well be a half per cent low, having been determined by the Berzelian method, owing to the difficulty of securing complete decomposition of the fine powder by a single treatment with sulphuric acid. Let it be permitted to balance the basic and acidic radicals by raising the fluorine, and to figure the ideal percentages on this basis. These become of interest when compared with the corresponding figures for prosopite from Altenberg and Pikes Peak as given below:

	Altenberg.	Pikes Peak.	Utah.
Al	23.37	22.02	22.74
Ca	16.19	17.28	16.85
F	35.01	33.18	29.95
H_2O	12.41	13.46	16.12
O	12.58	13.41	14.34
	....	....	100.00

If the assumptions made in the foregoing are justified, the Utah mineral is prosopite, and further evidence is afforded of the correctness of the view established by Penfield that fluorine and hydroxyl can mutually replace each other in many mineral species, for their relative proportions differ materially in the prosopite from the three known localities. The correctness of the formula as applied to the Colorado and Utah prosopite is, however, predicated, as said, on the unproven assumption that the material analyzed contains some admixed fluorite.

7. JEFFERSONITE.

Two brown substances associated with franklinite and other zinc minerals from Franklin Furnace, New Jersey, so alike in appearance as to have been taken for the same mineral species, were received from Mr. George L. English. One was a little duller than the other and proved to be a mixture of several minerals, according to Mr. F. L. Ransome of the U. S. Geological Survey, largely pseudomorphic after some micaceous mineral. From Professor Clarke's calculations, based on the following analysis, it might be a mixture of a calcium-aluminum garnet, troostite, and limonite. SiO_2 32.09, Al_2O_3 11.12, Fe_2O_3 5.16, MnO 15.85, ZnO 16.89, CaO 15.65, H_2O 2.15, MgO and alk. 1.12; total 100.00.

The other was of a richer and deeper brown, and showed such a pronounced cleavage or parting in one direction as to produce a lamellar structure. The luster was brilliant on these cleavage surfaces. Other directions of cleavage were apparent. The hardness was about 5.5 and the density 3.39 at 21.5° C. Before the blowpipe a fragment fused with difficulty to a light-colored blebby glass. Analysis gave:

SiO_2	51.70
Al_2O_3	.36
Fe_2O_3	.37
MnO	7.43
ZnO	3.31
CaO	23.68
MgO	12.57
Na_2O	.12
K_2O	trace
H_2O	.65
	100.19

TiO_2, FeO, P_2O_5 absent.

Neglecting the sesquioxides, alkalies, and water, this leads to the ratio $SiO_2 : RO = 1 : 1.02$, and the formula is that of a metasilicate $R''SiO_3$. According to Mr. English, the material submitted by him had been pronounced by Professor Penfield on the basis of qualitative tests to be jeffersonite, a manganese-zinc pyroxene, a statement supported by the analysis above given, although neither the color of the mineral nor its quantitative composition agree with the hitherto published data. In Dana's Mineralogy the color is given as "greenish black, on the exposed surface chocolate brown," the density as 3.36 on page 358, but 3.63 on page 360. The discoverers of the species, Keating and Vanuxem, give 3.50–3.55 for the density and 4.5 for the hardness. The present mineral presents all the evidences of being fresh and unaltered, yet it is brown throughout, and its analysis furnishes figures widely at variance with those of Herrmann and of Pisani, but giving a better metasilicate ratio than either of their analyses. Notwithstanding these discrepancies, there is no reason for ascribing to the mineral a new subspecies name. The analysis is chiefly valuable as showing a wide range of composition for the mineral.

8. ANORTHITE AND EPIDOTE.

In specimens collected by T. F. Lamb at Phippsburg, Maine, these two minerals *occur under unusual circumstances.* The mass of t material is a highly metamorphosed contact limestone, carrying an abundance of cinnamon garnet and occasionally a green pyroxene. Now and then there is embedded in the masses of garnet a dark-gray mineral, nearly black in some specimens, in brilliant plates which nowise suggest epidote. Epidote, however, it proved to be, as shown by the subjoined partial analysis, and as verified by Mr. J. S. Diller under the microscope. The anorthite, also determined optically by Mr. Diller, and analytically by Mr. George Steiger, is associated sometimes with the epidote and sometimes in coarse crystals only with the garnet. The analyses are as follows:

	Epidote.	Anorthite.
SiO_2	38.54	45.62
Al_2O_3	28.39	35.29
Fe_2O_3	6.89	....
FeO	.50	....
CaO	24.12	17.31
MgO	trace	....
Ignition	2.26	....
	100.70	98.22

In some ways the epidote resembles axinite, a mineral which has long been recorded as found at Phippsburg. Is the supposed axinite really epidote?

9. ROSCOELITE.

The rare mineral roscoelite has greatly needed reexamination, in order to reconcile the discrepancies between the analyses of Roscoe and Genth and to establish a satisfactory formula for this supposed vanadium mica. To the kindness of Mr. G. W. Kimble, of Placerville, California, I am indebted, through Mr. H. W. Turner, for specimens from the Stockslager mine, from which a limited amount of fairly pure material was picked out. This was then laboriously purified by the aid of Thoulet's solution, the result being a very nearly pure product weighing only 1.2 grams and having, after drying at 100° C., a density of 2.97 at 20° C.

Notwithstanding the small amount, it was possible by the exercise of care to make fairly satisfactory analyses.

With regard to the methods employed little need be said except as to the determination of the condition of the vanadium. For this purpose decomposition was effected by rather dilute H_2SO_4 in sealed tubes, the greatest care being taken to expel every trace of air from the powder and acid, and to seal the tube during passage of a current of CO_2. Otherwise it is impossible to prevent oxidation of a considerable part of the V_2O_3. In one case, unfortunately, the air could not have been fully expelled, for the solution after decomposition was blue instead of green and much less oxygen was required in titration than when the color was green.

The contents of the tube, still warm, were poured into fairly hot freshly boiled water and titrated rapidly. Iron and vanadium were then reduced by H_2S gas, the latter boiled out in a current of CO_2, and titration repeated on the hot liquid. The solution was then boiled with ammonia, the precipitate fused with Na_2CO_3, leached with water, and the residue again fused with Na_2CO_3 and leached to remove the last of the vanadium. This residue was then fused with $KHSO_4$,[1] dissolved in dilute H_2SO_4, boiled first with H_2S and then in a current of CO_2, and the liquid titrated for total iron. The solution held titanium which was then estimated colorimetrically.

The first of the titration results gave the effect of all iron, assuming its existence as FeO, and of all vanadium that might exist in a lower state of oxidation than V_2O_5. The second gave all iron as FeO and all vanadium as V_2O_4. Deduct from both the figure for FeO and the remainder gives that for vanadium. In this way two very concordant results were obtained for total vanadium as V_2O_4, which were supplemented by tests on portions used for other constituents, but only one was obtained for the vanadium as it exists in the mineral, a second being vitiated by evident oxidation during decomposition in the tube. As a check, however, a fresh sample of unpurified mineral was similarly treated, and it was found that fully nine-tenths of the vanadium existed as V_2O_3, a result confirming the single test on the purified material which showed 93.5 per cent as V_2O_3. It is not impossible that slight oxidation had taken place even in these cases, and I feel justified in assuming with Genth that the vanadium should be considered wholly as V_2O_3.

In the other portions analyzed the vanadium was likewise titrated in V_2O_4 condition, but only after separation from iron, titanium, and aluminum by fusion with Na_2CO_3, extraction with water and separation of dissolved alumina by ammonium carbonate. A second fusion of the residue and of the precipitated alumina was necessary in order to extract all the vanadium. These numerous manipulations render the figures for Al_2O_3 perhaps the least trustworthy of all, but the average given is probably not far from correct.

The iron is assumed to be present as FeO; and the titanium to belong to a foreign mineral, since a test on unpurified material gave much more, namely, 1.50 per cent TiO_2, without accompanying increase in FeO, which latter observation seems to exclude ilmenite as the source of the titanium.

Both the iron and magnesium are supposed to belong to the roscoe-

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[1] Any slight trace of vanadium remaining will impart a bright yellow color to the cold $KHSO_4$, fusion, a test which proved useful more than once during the analysis.

lite, since they were found by Genth in nearly the same amounts and no recognizable iron or magnesium minerals were noticed in the purified powder.

For comparison, the mean of Roscoe's analyses and that one of Genth's considered by himself to be his best are also given in the table below.

Very marked differences are apparent in the three analyses by different chemists. If titanium was present in the material analyzed by Genth and Roscoe, as is very probable, their high results for alumina are in great part at least accounted for. It is inconceivable how Genth obtained his value for water by ignition, since the mineral oxidizes when heated in air. In fact the oxidation in one of my own analyses, after allowing for loss of water as ascertained by direct weight, was almost what theory requires for the oxidation of V_2O_3 to V_2O_5 and of FeO to Fe_2O_3, or 5.14 per cent instead of 5.27 per cent. It may fairly be assumed that his water was weighed directly after expulsion by ignition of the powder. Roscoe's figures for water, if not for moisture, must be affected by error, probably arising from the unsuspected oxidation of vanadium.

Analyses of roscoelite.

	Hillebrand.						Genth.	Roscoe.	
Amount used	0.3000*g*.	0.2531*g*.	0.2635*g*.	*a*0.1560*g*	0.2038*g*.	Mean.			
SiO_2	45.30	45.04	......	......	......	45.17	47.69	SiO_2	41.25
TiO_2	.77	......	.77	......	.80	.78	......	V_2O_5	*b* 28.60
V_2O_3	23.90	24.00	......	24.09	24.06	24.01	20.56	Al_2O_3	14.14
Al_2O_3	......	11.74	11.34	......	......	11.54	14.10	Fe_2O_3	1.13
FeO	1.59	......	......	1.65	1.57	1.60	1.67	Mn_2O_3	1.15
MgO	1.64	......	......	......	......	1.64	2.00	CaO	.61
K_2O	......	10.41	10.32	......	......	10.37	7.59	MgO	2.01
Na_2O	......	.13	none	......	......	.06	.17	K_2O	8.56
Li_2O	......	ft. tr.	......	......	......	ft. tr.	trace	Na_2O	.82
								Water	1.08
H_2O below 105° C.	.40	......	......	......	......	.40	......	Moisture	2.27
H_2O 105-280° C	.17	......	4.29	......	......	.17	4.96 ign.		
H_2O above 280°C.	......	......		......	......	4.12			
Fl	......	......	......	......	......	none	......		
						99.86	98.76		101.62

a 4.94 per cent oxygen used for complete oxidation instead of 5.27 needed for all V as V_2O_3 and Fe as FeO.

b Equivalent to 23.59 per cent V_2O_3.

From the column of means of my own analyses the following ratios are obtainable:

SiO_2	.753
V_2O_3	.159
Al_2O_3	.113
FeO	.022
MgO	.041
K_2O	.110
H_2O	.229

The entire absence of manganese and of calcium in my own and Genth's samples tends to confirm the suspicion that Roscoe's material was far from pure. It is to be remarked, however, that my figures for vanadium agree quite closely with his and differ widely from Genth's.

Discrepancies of this kind are not necessarily to be ascribed to faulty analyses. It is well enough known that in any one species of mica various molecules must sometimes be assumed to exist in different proportions, and the general formula for such a species can only be arrived at by comparison of a series of analyses of different varieties. Hence, in view of the lack of any simple ratios, the deduction of a definite and final formula from my data is not justifiable. Further analyses are needed of new and very pure material from other locations, even if these be not far removed from the source of the present material. Nevertheless, in the hands of an expert very unpromising data may often be made to afford positive indications, and that this is true in the present case the following discussion by Prof. F. W. Clarke clearly shows:

CHEMICAL CONSTITUTION OF ROSCOELITE, BY F. W. CLARKE.

The ratios given in the foregoing new analysis, used directly, lead to the following empirical formula for roscoelite:

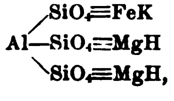
$$H_{458}K_{220}Fe_{22}Mg_{41}Al_{226}V_{318}Si_{753}O_{2724}.$$

Here H to K and Mg to Fe are as 2 to 1. Between O and Si, however, the ratio is not simple, and lies below the orthosilicate and above the trisilicate proportion. Since in many micas the groups SiO_4 and Si_3O_8 are replaceable, that suggestion may be followed out here; and then the formula reduces to

$$R'_{678}R''_{63}Al_{226}V_{318}(SiO_4)_{536}(Si_3O_8)_{71}.$$

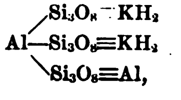
From this expression, applying Clarke's mica theory, the mineral may be regarded as a molecular mixture of the three compounds

1.



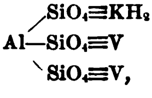
$$Al\begin{cases}SiO_4\equiv FeK\\ SiO_4\equiv MgH\\ SiO_4\equiv MgH,\end{cases}$$

2.



$$Al\begin{cases}Si_3O_8\equiv KH_2\\ Si_3O_8\equiv KH_2\\ Si_3O_8\equiv Al,\end{cases}$$

3.



$$Al\begin{cases}SiO_4\equiv KH_2\\ SiO_4\equiv V\\ SiO_4\equiv V,\end{cases}$$

in the ratio 21:22:159, or nearly 1:1:8. Upon reducing the analysis to 100 per cent, after throwing out the TiO_2 and the water lost below 280° as extraneous, we get the following comparison between the results found and the theoretical composition:

	Found.	Reduced.	Calculated.
SiO_2	45.17	45.88	45.52
TiO_2	.78	....	....
V_2O_3	24.01	24.39	24.64
Al_2O_3	11.54	11.73	11.62
MgO	1.64	1.66	1.72
FeO	1.60	1.63	1.55
K_2O	10.37	10.53	10.81
H_2O, 280°—	.57	....	....
H_2O, 280°+	4.12	4.18	4.14
	99.80	100.00	100.00

This comparison, based on the ratio 21:22:159, is as satisfactory as could be expected.

Of these component molecules the first represents the normal phlogopite type, the second is a trisilicate alkaline biotite, and the third, which forms 74.5 per cent of the whole mass, is a muscovite in which two-thirds of the aluminum have been replaced by vanadium—in short, a vanadium muscovite. Ordinary muscovite is $Al_3(SiO_4)_3KH_2$, and whether a corresponding $V_3(SiO_4)_3KH_2$ exists can be determined only by analyses of roscoelite from other localities, and so learning its range of variation. That vanadium may replace aluminum is shown by the fact that Piccini has prepared true vanadium alums. That roscoelite is essentially a vanadium muscovite seems to be fairly well established. As for the molecule $Al_2(Si_3O_8)_3K_2H_4$, its existence is indicated in some other micas, and in Simmler's "helvetan" it seems to be the dominant molecule.

NOTE.—A full discussion of the mode of occurrence of roscoelite, with historical data relative to the species, is given by Mr. H. W. Turner in the American Journal of Science, 4th series, Vol. VII, June, 1899, p. 455.

10. MARIPOSITE.

Samples of the peculiar micaceous mineral named mariposite by Silliman were collected at the Josephine mine, Bear Valley, Mariposa County, California, by H. W. Turner in 1894.[1] According to Turner it resembles talc optically, but chemically it appears to be one of the ill-defined substances known, for want of a more precise name, as pinite. Two varieties were analyzed—one white, the other green, but neither analysis leads to any definite formula. The data are as follows:

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[1] Occurrence described by Turner in Am. Jour. Sci., 3d series, Vol. XLIX, 1895, p. 377.

	Green.	White.
SiO_2	55.35	56.79
TiO_2	.18	25.29
Al_2O_3	25.62	
Cr_2O_3	.18	none
Fe_2O_3	.63	1.59
FeO	.92	
CaO	.07	.07
MgO	3.25	3.29
K_2O	9.29	8.92
$(NaLi)_2O$	.12	[a] .17
H_2O	4.52	4.72
	100.13	100.84
Sp. gr	2.817, 29°.5	2.787, 28°.5

[a] Contains some K_2O.

No water was lost below 300°. The reaction for lithia was very strong. The color of the green mariposite is evidently due to chromium.

11. TWO SULPHATES FROM MONTANA.

Mr. W. H. Weed collected in the St. Paul mine, near Whitehall, Montana, a magnificent specimen of a compact soluble fibrous sulphate, supposed to be melanterite. It seemed to be a filling between fragments of broken rock. Outwardly it was white from dehydration, but at some depth the unaltered green mineral was to be found. This had the following composition:

Al_2O_3	4.34
FeO	9.04
NiO	.03
MnO	2.62
ZnO	1.06
CuO	.05
CaO	.09
MgO	3.07
Na_2O	.07?
SO_3	21.88
Cl, CO_2	none
H_2O	48.84
Insol	.16
	99.25

Of the water, 10 per cent escaped in twenty-four hours over sulphuric acid and only 0.4 per cent more in another like period, but a total of 14.4 per cent after ten days' uninterrupted exposure. The water thus lost is very slightly reabsorbed on exposure to air.

From calculations by Prof. F. W. Clarke the substance may be regarded as a mixture of alunogen or the halotrichite group, with salts of the melanterite group, the empirical formula being nearly

$$(Fe, Mn)_4(Zn, Mg)_3Al_2(SO_4)_9 . 65H_2O.$$

The outer white zone of the specimen contained only 39.62 per cent of water.

The second sulphate examined was a beautiful sky-blue stalactite from the Anaconda mine at Butte, collected by Mr. G. W. Tower. Its composition was as follows:

CuO	9.32
FeO	.18
MgO	.08
Al_2O_3	10.67
SO_3	35.05
P_2O_5	1.13
As_2O_5	.07
H_2O	43.44
Insol	.06
	100.00

The stalactite was of some size, and was most readily soluble in cold water, the solution giving a strong acid reaction. The calculated ratio is strongly acid, showing either a mixture of highly acid salts or of normal salts with free acids.

ON THE CHLORONITRIDES OF PHOSPHORUS AND THE METAPHOSPHIMIC ACIDS.

By H. N. STOKES

I. ON TRI- AND TETRAPHOSPHONITRILIC CHLORIDES.[1]

"Chlorophosphuret of nitrogen" (Chlorphosphorstickstoff) was discovered in 1832 by Liebig,[2] while attempting to prepare amides of phosphoric acid by acting on phosphorus pentachloride with gaseous ammonia and with ammonium chloride. Analysis[3] led to the formula $P_3N_2Cl_5$, and he observed that the compound could be distilled with steam or boiled with acids or alkalies without appreciable decomposition—properties unique in a phosphorus-chlorine compound.

Liebig did not pursue the subject much further, but at his suggestion Gladstone[4] in 1849 continued the study of the phosphorus-nitrogen compounds and, incidentally, of chloro-phosphuret of nitrogen. In his papers on this body[5] Gladstone detailed a method of preparation from phosphorus pentachloride and ammonium chloride, and pointed out some of its properties—among them its decomposition in aqueous ether or by alcoholic alkalies into hydrochloric acid and a nitrogenous compound, deutazophosphoric acid. Gladstone adopted Liebig's formula, $P_3N_2Cl_5$. The correctness of this was disputed on theoretical grounds by Laurent[6] and Gerhardt,[7] and the formula $PNCl_2$ suggested. At a later date Gladstone and Holmes[8] revised the work of the former and adopted Laurent and Gerhardt's formula, at the same time showing, on the basis of the vapor density, that it must be tripled: $P_3N_3Cl_6$.

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[1] The following work was begun in the laboratory of the School of Pharmacy, Northwestern University, Chicago, and continued in the laboratory of the United States Geological Survey. I wish to express my sincere thanks to Prof. J. H. Long, of the former institution, for his kindness in permitting me to work in his laboratory.

[2] Liebig-Wöhler, Briefwechsel, Vol. I, p. 63; Ann. Chem. (Liebig), Vol. XI, 1834, p. 146.

[3] The part of Wöhler in this investigation seems to have consisted merely in making the analyses for Liebig.

[4] Quart. Jour. Chem. Soc. London, Vol. II, 1850, p. 121.

[5] Ibid., Vol. III, pp. 135, 353; Ann. Chem. (Liebig), Vol. LXXVI, p. 74; Vol. LXXVII, p. 314.

[6] Compt. rend., Vol. XXXI, 1850, p. 356, and Compt. rend. des Trav. de Chimie, 1850, p. 387.

[7] Compt. rend. des Trav. de Chimie, 1851, p. 30; Ann. Chim. Phys. [3], Vol. XVIII, p. 204, note.

[8] Jour. Chem. Soc. London, [2], Vol. II, 1864, p. 225.

Later, Wichelhaus[1] confirmed the results of Gladstone and Holmes, and suggested the structural formula

$$\begin{array}{c} NPCl_2 \\ Cl_2PN—NPCl_2 \end{array},$$

and A. W. Hofmann[2] and Couldridge[3] added some further observations.

By distilling under diminished pressure the reaction product of phosphorus pentachloride and ammonia gas Besson[4] obtained a substance of the composition $PNCl_2$, which he describes as "un corps solide donnent par sublimation des cristaux très réfringents, fusibles à 106°." The low melting point would indicate a body other than $P_3N_3Cl_6$ (melting point 114°), but as the latter is the chief volatile product formed under ordinary circumstances it may be regarded as an open question whether Besson's compound is identical with Liebig's.

Finally, White[5] and Gilpin[6] observed it as a secondary product of the action of phosphorus pentachloride on acid ammonium orthosulphobenzoate, doubtless originating in the action of the ammonia.

None of these investigations have thrown much light on the constitution of the chlorophosphuret or on its relation to other phosphorus compounds.

My attention being called to this substance while engaged in studying the amides of phosphoric acid, I have prepared it in large quantity with a view to further investigation. Although the experiments have not progressed far enough to establish any definite constitutional formula, they show that the chlorophosphuret is by no means as intractable as has been supposed, and that it is one of an homologous series of compounds having the general formula $(PNCl_2)_x$, which are the chlorides of an homologous series of acids $(PNO_2H_2)_x$, the metaphosphimic acids. From the reaction product of phosphorus pentachloride and ammonium chloride I have thus far isolated the body $(PNCl_2)_4$, which almost equals $(PNCl_2)_3$ in stability, and which yields, on saponification, an acid $(PNO_2H_2)_4$, also an extremely stable substance. A further product of the reaction is a stable, oily chloride $(PNCl_2)_x$ of high, but as yet unknown, molecular weight. I have also obtained from Liebig's chlorophosphuret the corresponding acid $(PNO_2H_2)_3$, an intermediate chlorhydrine $P_3N_3Cl_4O_2H_2$, and a chloramide $P_3N_3Cl_4(NH_2)_2$. The object of the present paper is mainly to describe the preparation and properties of the chlorides, the consideration of the acids being deferred to a later occasion.

Nomenclature.—In view of the large number of phosphorus-nitrogen compounds actually known or theoretically possible, it is desirable to have a more definite nomenclature than has thus far been used. I

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[1] Ber. Deutsch. chem. Gesell., Berlin, Vol. III, 1870, p. 163.

[2] Ibid. Vol. XVII, 1884, p. 1910.

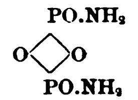
[3] Jour. Chem. Soc. London, Vol. LIII, 1888, p. 398.

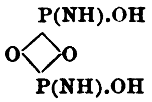
[4] Compt. rend., Vol. CXIV, 1892, pp. 1264, 1480.

[5] Dissertation, Baltimore, 1891, p. 13.

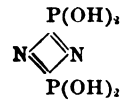
[6] Dissertation, Baltimore, 1892, pp. 7, 16.

have proposed[1] to reserve the name amido-orthophosphoric acid for the ortho acid in which one hydroxyl is replaced by the amido group, and to call the isomeric form $P(NH)(OH)_3$ orthophosphimic acid. By analogy an acid  $P(NH){\scriptstyle\begin{matrix}=O\\ \diagdown OH\end{matrix}}$ might be named metaphosphimic acid. Corresponding to the polymeric metaphosphoric acids we may imagine an homologous series of metaphosphimic acids, but for each of these several forms would be possible, according as the polymerization is effected by means of oxygen or of nitrogen atoms, assuming them to be otherwise built on the same general type. For example, an acid of the formula $P_2N_2O_4H_4$, with cyclic structure, might have any of the following constitutional formulas, omitting mixed forms:


(a)
Dimetaphosphoryl amide.


(b)
———


(c)
Dimetaphosphimic acid.


(d)
Diphosphonitrilic acid.

(a) and (b) represent the amide of a dimetaphosphoric acid with its desmotropic form; (c) and (d) represent the two forms of an acid isomeric with the former, but not directly derivable from a dimetaphosphoric acid. In the former class, phosphorus is united by means of oxygen; in the latter, by nitrogen. (b) and (c) are polymers of (PO) (NH) (OH) while (d) is a polymer of an acid $N \equiv P(OH)_2$, which we may call phosphonitrilic acid. Acids of the type (c) I call x-metaphosphimic acids, and those of the type (d), x-phosphonitrilic acids.[2]

In the chlorides $P_3N_3Cl_6$ and $P_4N_4Cl_8$, phosphorus must be united by means of nitrogen[3] (in the absence of oxygen); hence also in all probability in the acids derived from them. The direct replacement of chlorine by hydroxyl would result in phosphonitrilic acids, but as the type (c) is equally plausible, in the absence of definite experimental grounds, I call them, provisionally, metaphosphimic acids. For the chlorides themselves, instead of the old term chlorophosphuret of nitrogen, which is no longer characteristic, the more definite names tri- and tetraphosphonitrilic chloride may be used.

EXPERIMENTAL PART.

Preparation of the chlorides.—The theoretical yield of triphosphonitrilic chloride is 55.5 per cent of the phosphorus pentachloride; in reality, it falls far below this, no matter what process may be employed, and at best is but a by-product. Gladstone[4] states the yield as

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[1] Am. Chem. Jour., Vol. XVI, p. 124, note.

[2] Ix = mono-, di-, tri-, etc.

[3] Unless we assume P to be joined to P, and N to N, a view which is not supported by their general behavior.

[4] Quart. Jour. Chem. Soc. London, Vol. III, p. 135; Ann. Chem. (Liebig), Vol. LXXVI, p. 76.

about 6 per cent of the pentachloride (11 per cent of the theoretical), when 1 molecular weight is distilled with 8 molecular weights ammonium chloride. Couldridge[1] obtained by a similar method a maximum yield of 10 per cent of the pentachloride (18 per cent of the theoretical). As a large excess of ammonium chloride is used, much "phospham" is formed. A modification by Gladstone and Holmes,[2] consisting in acting on the pentachloride with mercuric chloramide, gave no better results.

I made numerous experiments in sealed tubes at 200°–260°, using sal ammoniac and pentachloride in theoretical proportions. In this case there is no formation of "phospham," but the yield of the desired body is not increased—in fact, seems to be even less than by distilling with an excess of ammonium chloride from an open retort. What results is a mixture of chloronitrides, largely crystalline, but of various degrees of solubility and stability toward water, of which but a very small portion is volatile with steam. A study of this mixture would, in all probability, lead to the discovery of other members of the series $(PNCl_2)_x$.

I finally adopted a slight modification of Gladstone's original method: A mixture (which need not be very intimate) of 1 part pentachloride and 2 parts dry ammonium chloride is rapidly heated in a tubulated retort (one-third filled) fitted to a receiver containing water, which is connected with one or two Woulff's bottles, with water, to condense the small portions carried over with the escaping hydrochloric acid. The water in the receiver should be gently agitated occasionally in order to break up the crust forming on the surface. When the decomposition is about half finished the heating is interrupted and the hard cake of phospham and sal ammoniac turned over with a rod inserted through the tubulure; this is necessary, as it is so poor a conductor that the bottom of the retort melts before the upper portions of the cake are affected. Heating must not be continued too long, because the subliming ammonium chloride acts on the chlorides condensed in the neck of the retort. After cooling, the substances condensed in the neck are removed by scraping and injecting hot water through the tubulure. The yield varies considerably, according to the quantity of mixture taken; the less the amount, the greater the yield. I have obtained as high as 11.5 per cent. Practically it is not desirable to push this too far, and I have obtained the most satisfactory results by distilling 200 grams of mixture at a time. The proportion of ammonium chloride should not be less than 2 parts; otherwise much pentachloride sublimes unchanged. The distillate, after washing with water, is by no means pure triphosphonitrilic chloride; it is a mixture of chlorides, of which about one-half is quite stable toward cold water, but decomposed on distilling with steam. During this operation nearly all the triphosphonitrilic chloride, $P_3N_3Cl_6$, is deposited as a hard crust in the con-

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[1] *Jour.* Chem. Soc. London, Vol. LIII, p. 399.

[2] Ibid. [2], Vol. II, p. 227.

denser. Distillation is continued only as long as much substance passes over; during the later stages large needles—mainly the new chloride, $P_4N_4Cl_8$—slowly collect in the condenser. There remain in the flask, besides a strongly acid liquid, a little solid material, consisting partly of phospham, partly of the crystalline acid ammonium tetrametaphosphimate, $P_4N_4O_8H_6(NH_4)_2$, and a considerable amount of oil, which solidifies, on cooling, to a crystalline cake of the compound $P_4N_4Cl_8$, impregnated with an oil of the same empirical composition.

The distillate, consisting of triphosphonitrilic chloride, mixed with about 5 per cent of tetraphosphonitrilic chloride, is dried, and an approximate separation effected by systematic recrystallization from benzene. This solvent has proved the most satisfactory, because the chlorides, in benzene solution, are scarcely affected by water, and no care need be taken to exclude it completely; aqueous ether, on the contrary, acts with considerable ease. The triphosphonitrilic chloride is pure after three or four recrystallizations, the tetraphosphonitrilic chloride accumulating in the mother liquors, the residues from which are again subjected to distillation with steam, the substance remaining in the flask being added to the first residue.

Apart from its influence on the melting point, the presence of very small quantities of the new body in the triphosphonitrilic chloride is readily detected by dissolving in alcohol-free ether and agitating for several hours with a little water, the tetraphosphonitrilic chloride being indicated by the formation in the water of microscopic needles of the difficultly soluble tetrametaphosphimic acid.

The residue from the distillation with steam is sucked out, whereby most of the oily chloride runs through with the water, and may be collected. The substance is then dried, the tetraphosphonitrilic chloride extracted with benzene and purified by several recrystallizations from this solvent. The residue left by the benzene, treated with dilute ammonia, leaves amorphous substances, and gives up tetrametaphosphimic acid, which is thrown down, on acidifying, as its acid ammonium salt. It may be mentioned here that the affinity of this acid for ammonia is such that its acid salt remains undecomposed even in large excess of hot 10 per cent nitric acid.

The yield of pure chlorides (from 9 kilograms of phosphorus pentachloride) was $P_3N_3Cl_6$, 6.9 per cent of the pentachloride, $P_4N_4Cl_8$, 0.76 per cent of the pentachloride, of which 0.42 per cent was obtained from the residue and 0.34 per cent from the crude steam distillate; these are respectively 12.4 and 1.4 per cent of the theoretical. A further small amount of tetraphosphonitrilic chloride was decomposed during distillation and, in part, recovered as tetrametaphosphimic acid. The yield of oily chloride was not determined, but it was approximately 1 per cent of the pentachloride.

It is not easy to give a reason for the relatively much higher yield of the triple phosphonitrilic chloride. Doubtless more of the quadruple compound is formed than is actually obtained, which, because of its less volatility, fails to distill over before it is attacked by the ammonium chloride, and I have also mentioned the simultaneous formation of large quantities of chlorides, unacted on by cold, but decomposed by boiling water. Still, it seems that there is some cause leading to the predominant formation and greater stability of this body, perhaps analogous to that acting in the case of the aromatic hydrocarbons. The proof that $P_3N_3Cl_6$ is a cyclic compound has not been found, but the occurrence of the number 6 in each case (C_6 and P_3N_3) is possibly more than a mere coincidence. Tetraphosphonitrilic chloride is also possessed of great stability, but I have observed, in various connections, that its chlorine is less firmly held than in the triple compound. The reverse appears to be true of the derived acids, $P_4N_4O_8H_8$ being more stable than $P_3N_3O_6H_6$.

Analytical methods.—The analysis of these bodies presents no difficulty. The chlorides, which volatilize on heating, are gently warmed with dilute alcoholic soda or potash. In this solution chlorine is directly determined as silver chloride; phosphorus is determined after evaporating off the alcohol, either by fusing the residue with sodium carbonate or by boiling for one or two hours with strong sulphuric acid, either of which converts it wholly into phosphoric acid. Nitrogen is determined as ammonia after acidifying the saponification product with hydrochloric acid, evaporating the alcohol, and boiling the residue with strong sulphuric acid. Experiment showed that no ammonia is evolved during saponification. In the case of the acids and other nonvolatile derivatives, the alcoholic saponification is omitted and the substance decomposed either by boiling with concentrated sulphuric acid, or fusing with sodium carbonate, the precaution being taken in the latter case first to moisten the mixture in the crucible. Owing to the strong reducing action of the imido group at high temperatures, these substances can not be fused alone in platinum without risk to the crucible. This is true even of the salts, which should give pyro- or metaphosphates on ignition.

The chlorides.—As triphosphonitrilic chloride has been the object of previous investigation, and as I have begun several lines of investigation with the object of explaining its nature and relations, I state here only a few incidental observations.

This chloride, as was early observed, has great crystallizing power. The rhombic crystals have been measured by Miller[1] and by Groth.[2] When pure it tends to form large, thick prisms. I have obtained these (from benzene) as much as 8 centimeters long and 2 centimeters wide, their further growth being hindered only by the size of the flask. When impure, it tends to form rhombic or 6-sided plates. It fuses at 114° (corr.), while the quadruple chloride, $P_4N_4Cl_8$, fuses at 123.5° (corr.), but a

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[1] Jour. Chem. Soc. London [2], Vol. II, p. 227.

[2] Ber. Deutsch chem. Gesell., Berlin, Vol. III, p. 166.

mixture of equal parts is liquid below 90°. The corrected boiling point is 256.5° at 760 millimeters pressure. Besides the solvents else where mentioned (for some of which quantitative data are given below), warm glacial acetic acid dissolves it readily. On boiling this solution with zinc dust some phosphuretted hydrogen is evolved. Hot concentrated sulphuric acid dissolves it easily. On boiling, some is decomposed, but the greater part distills off unaltered. The rather pleasant aromatic odor of its vapor has long been known. Although this is by no means irritating, inhaling it in any considerable amount is likely to be followed in two or three hours by alarming difficulty in breathing, succeeded by persistent irritation of the air passages. This insidious property renders care necessary in working with it in large quantities or for extended periods, all the more as the nose is the best instrument for detecting it.

A vapor-density determination by Victor Meyer's method at 360° in dry hydrogen gave 12.35 (calculated 12.01). The volatilization is complete, but on long boiling in air a little solid substance is deposited. Ethyl bromide and sodium are without action on the ethereal solution. Brombenzene and sodium acts slowly on the ether or benzene solution, forming a mixture of brownish amorphous organic substances, in part soluble, in part insoluble in ether, in which only a portion of the chlorine is replaced. No smooth reaction could be obtained.

Zinc ethyl, as observed by Couldridge,[1] is without action at ordinary temperature. On heating together in a sealed tube a violent reaction occurs, accompanied by liberation of gas and carbonization. If the zinc ethyl be diluted with 2 volumes benzene, a mixture of complex addition products is formed on heating, which are left on evaporating as a no longer soluble white vitreous mass, containing zinc, phosphorus, nitrogen, chlorine, and ethyl. This is decomposed by caustic potash, which liberates a mixture of oily bases of a disagreeable, sweetish odor, which are for the greater part decomposed on distillation, and which dissolve in cold water, and are thrown out on warming. These are slowly decomposed, on heating with hydrochloric acid, into ammonia and what appear to be highly complex phosphinic acids, containing nitrogen. At 170° considerable quantities of combustible gases, and of mono-, di-, and triethyl phosphine are formed by the action of zinc ethyl, in addition to a small amount of a crystalline basic substance containing nitrogen, and showing much the same properties as the oily substances alluded to. The yield was very minute.

Action of water on triphosphonitrilic chloride.—By decomposing chlorophosphuret of nitrogen with aqueous ether,[2] or with alcoholic alkalies,[3] Gladstone obtained a substance which he named deutazophosphoric

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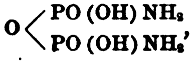
[1] Jour. Chem. Soc. London, Vol. LIII, p. 898.

[2] Quart. Jour. Chem. Soc. London, Vol. III, pp. 135, 354; Ann. Chem. (Liebig), Vol. LXXVI, p. 79; Vol. LXXVII, p. 315.

[3] Jour. Chem. Soc. London, [2], Vol. II, p. 231.

acid. He afterwards obtained this in larger quantity by treating phosphorus oxychloride with dry ammonia, and assigned to it the formula



$$O\begin{cases}PO(OH)NH_2\\PO(OH)NH_2\end{cases}$$

and the name pyrophosphodiamic acid. The formation of such an acid can only be due to a deep decomposition of the molecule.

Although unacted on by water alone or by anhydrous ether alone, I have found that a smooth decomposition is easily effected by dissolving the chlorophosphuret in alcohol-free ether, and shaking this solution a long time with water, whereby intimate contact is effected. The final products are hydrochloric acid and an acid in which the chlorine is wholly replaced by oxygen and hydrogen, without further change. I have named this substance, $P_3N_3O_6H_6$, *trimetaphosphimic acid.*[1] If the water contain bases or acetates in solution, the salts are directly obtained. As the acid will be described in a separate section, I mention here only that it is extremely soluble and totally devoid of crystallizing power, but forms some salts of characteristic crystalline form, and has a strong tendency to form double salts, one of these, $P_3N_3O_6H_3NaBa$, giving especially fine crystals.

As intermediate products, chlorhydrines have been observed. Theoretically, five of these are possible, one of which I have isolated, namely:

Triphosphonitrilic tetrachlorhydrine, $P_3N_3Cl_4O_2H_2$.—One part triphosphonitrilic chloride is dissolved in 10 parts alcohol-free ether, and the solution agitated with about one-third its volume of water for six to eight hours, best by means of a small turbine. The water then contains hydrochloric acid and trimetaphosphimic acid, and the ether contains the chlorhydrines and unchanged chloride. The ether is dried over calcium chloride, and the greater part distilled off in the water bath, the latter portions being removed at ordinary temperature by a current of dry air. The residue consists of unchanged chloride, the chlorhydrine in question, and small quantities of others. The greater part of the chloride is removed by a little benzene, and the residual chlorhydrine well washed with carbon disulphide. The yield depends somewhat on the time the water has acted, but as there is a continuous conversion of chloride into chlorhydrine, and of the latter into trimetaphosphimic acid, the amount present at any one time is not great. Under the above conditions it was about 10 per cent of the theoretical, fully one-half the chloride being recovered.

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[1] According to Mente (Ann. Chem. (Liebig), Vol. CCXLVIII, pp. 241, 244), Gladstone's pyrophosphodiamic acid is really , *i. e.*, dimetaphosphimic acid, which has the same empirical composition as trimetaphosphimic acid. Mente did not obtain his acid from triphosphonitrilic chloride, but from phosphorus oxychloride, and it is not clear that it is really identical with Gladstone's acid from chlorophosphuret of nitrogen. The independent existence and stability of the tetra-acid affords a *pre*sumption that other members of the series can exist also.

Analysis gave:

	Calculated for $P_3N_3Cl_4O_2H_2$.	Found.		
		1.	2.	3.
P	29.94	....	30.00	30.04
N	13.54	....	13.74	....
Cl	45.59	45.38	48.18	48.37

2. P:N:Cl=3:3.03:4.20. 3. P:Cl=3:4.23.

1, 2, and 3 represent different preparations, 1 having been further purified by recrystallizing from benzene.

The chlorhydrine forms a white sandy powder, consisting of well-defined microscopic prisms. It is very difficultly soluble in boiling benzene, and is insoluble in benzine and in carbon disulphide. With the latter it shows a peculiar behavior. Its refractive index is such that it nearly vanishes and apparently dissolves when brought into the disulphide; on decanting the liquid the moist powder shows beautiful iridescence. Alcohol dissolves it easily and in ether it is much more soluble than the original chloride, the presence of a trace of ether vapor causing it to liquefy instantly. Water dissolves it somewhat slowly, but abundantly, the solution containing hydrochloric acid and trimetaphosphimic acid, the latter being left on rapid evaporation on the water bath or in vacuo, as a transparent, easily soluble, gummy residue. From the aqueous solution of the chlorhydrine, salts of trimetaphosphimic acid were directly prepared and analyzed. The chlorhydrine is quite stable in the air at ordinary temperature,[1] but on heating at 100° it slowly increases in weight through absorption of moisture, undergoing decomposition with formation of ammonium chloride. It shows no definite melting point, but, on rapid heating, liquefies imperfectly, gives off hydrochloric acid, and leaves a mixture of amorphous substances of different degrees of solubility in water.

Other chlorhydrines, partly crystalline, appear to be formed simultaneously, but in relatively small amount, and their isolation is attended with difficulties. Whether the 2 chlorine atoms removed are associated with the same or with different phosphorus atoms remains to be determined.

Triphosphonitrilic chloramide, $P_3N_3Cl_4(NH_2)_2$.—The tendency to the formation of stable bodies in which one-third of the chlorine is substituted, observed in the case of the chlorhydrine, appears if triphosphonitrilic chloride be acted on in ether solution by ammonia. Gaseous ammonia may be used, but this is by no means necessary, aqueous ammonia producing the same result. If the chloride be dissolved in ether and

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[1] On keeping for several months, a slight formation of ammonium salts was observed.

shaken a short time with 10 per cent ammonia, but one amide appears to be formed. As soon as a few drops of the ether solution leave, on evaporation, a residue completely soluble in hot water, indicating complete transformation of the chloride, it is dried over calcium chloride and allowed to evaporate spontaneously, whereby a substance crystallizing in needles is deposited. The product, which appeared homogeneous on microscopic examination, was directly analyzed.

	Calculated for $P_3N_3Cl_4(NH_2)_2$.	Found.
P	30.12	29.51
N	22.72	21.98
Cl	45.86	44.83

P : N : Cl = 3 : 4.94 : 3.98.

The yield was 67 per cent of the theoretical, some of the chloride having been further decomposed and dissolved by the ammonia.

Triphosphonitrilic chloramide is quite soluble in ether, and less soluble in hot benzene, from which it crystallizes in long tufts of delicate hairs. It is easily soluble in alcohol, and from the concentrated alcoholic solution it is precipitated by water. Its stability toward water is striking; cold water dissolves it slightly, and, on rapid evaporation, even on the water bath, much is deposited unaltered; it can even be recrystallized from hot water, though with much decomposition, in needles or short prisms. Its stability in aqueous solution is further indicated by the failure of silver nitrate to give a precipitate except on boiling. Aqueous ammonia has but little action in the cold. On heating its aqueous solution, ammonium chloride and a sirupy acid result. Cold dilute acids have no marked solvent action. It undergoes change gradually at ordinary temperature, and rapidly on heating, without fusing, ammonium chloride and an infusible white substance being the products in the latter case.

Couldridge,[1] by acting on fused triphosphonitrilic chloride with gaseous ammonia, obtained a substance which he regarded as phospham. Both Couldridge and A. W. Hofmann[2] express the opinion that phospham has the composition expressed by the formula $P_3N_3(NH)_3$. I regard this as too sweeping. Apart from the fact that its composition varies with the mode of preparation,[3] it is likely that the true phospham is a mixture of an homologous series of imides $(PN.NH)_x$, derivable from the homologous phosphonitrilic chlorides $(PNCl_2)_x$.

Tetraphosphonitrilic chloride, $P_4N_4Cl_8$.—The new chlorophosphuret of

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[1] Jour. Chem. Soc. London, Vol. LIII, p. 398.

[2] Ber. Deutsch. chem. Gesell., Berlin, Vol. XVII, p. 1911.

[3] Salzmann : Ber. Deutsch. chem. Gesell., Berlin, Vol. VII, p. 494.

nitrogen, prepared as above described, gave the following results on analysis:

	Calculated for $P_4N_4Cl_8$.	Found.	
		1.	2.
P	26.77	26.89	27.00
N	12.11	12.35	12.36
Cl	61.12	61.17	61.28

1. P:N:Cl=1:1.01:1.99. 2. P:N:Cl=1:1.01:1.99.
1 and 2 represent different preparations.

The vapor density, determined by Victor Meyer's method, in dry hydrogen at 360°, was:

	Calculated for $P_4N_4Cl_8$.	Found.
Density	16.03	16.20

I am indebted to Mr. B. H. Hite, of the Johns Hopkins University, for a series of determinations of the molecular weight by the ebullioscopic method. The following is his statement of the results:

Solvent: Benzene. Molecular elevation, 26.7.

Substance $(PNCl_2)_x$.

Grams solvent.	Grams substance.	Concentration.	Elevation (degrees).	Molecular weight found.	Percentage variation from 464.
37.618	1.1620	3.09	0.177	466	+0.4
37.618	1.4820	3.94	.227	463	— .2
37.987	1.1107	2.92	.167	467	+ .7

These results agree well with the quadruple formula.

The following table gives some of the constants compared with those of $P_3N_3Cl_6$.

	$P_3N_3Cl_6$.	$P_4N_4Cl_8$.
Specific gravity	a 1.98	b 2.18
Melting point (corrected)	114°	123.5°
Boiling point (760 mm. pressure; thermometer wholly in vapor), degrees	256.5	328.5
100 parts ether at 20° dissolve	46.5	12.3
100 parts benzene at 20° dissolve	57.4	20.9

a Gladstone. b At $\frac{24^\circ}{24^\circ}$

Tetraphosphonitrilic chloride forms colorless, brittle prisms, not easily wet by water, and therefore having a strong tendency to float. Superficially, these are not always to be distinguished from those of triphosphonitrilic chloride, but in a general way it may be said that they tend to be much smaller, and are to be measured by millimeters rather than centimeters, and that they tend to vary toward an acicular rather than a tabular form. In alcohol and in benzene it is much less soluble than $P_3N_3Cl_6$. Hot concentrated sulphuric acid dissolves it, and, on boiling, much hydrochloric acid is evolved, but some of the substance sublimes out unchanged. It may be recrystallized from glacial acetic acid; on boiling this solution with zinc dust a little hydrogen phosphide is given off, and the solution contains ammonia. It is noticeably volatile at its fusing point, its vapor having an odor suggesting, but perceptibly differing from, that of triphosphonitrilic chloride, and less aromatic. The fused substance solidifies to a mass of nearly parallel needles, while triphosphonitrilic chloride gives transparent plates. As mentioned above, its volatility with steam is comparatively slight. If boiled for some time in contact with air, a minute amount of substance is formed, which swells enormously to a clear gelatinous mass in benzene. Alcohol converts it slowly into an oily ether, which aqueous ammonia, on warming, saponifies to tetrametaphosphimic acid.

Action of water on tetraphosphonitrilic chloride.—In its chemical behavior it resembles triphosphonitrilic chloride. It is scarcely acted on by boiling water, yet on prolonged boiling a minute amount of tetrametaphosphimic acid is formed; aqueous fixed alkalies are without perceptible action, while alcoholic alkalies decompose it easily, but the product is mainly something else than tetrametaphosphimic acid.

A smooth decomposition is effected by dissolving in ether and shaking protractedly with water. The first products of this action consist of chlorhydrines, which remain dissolved in the ether, are crystalline, and readily soluble in cold water, from which solution tetrametaphosphimic acid is rapidly deposited in the form of thick needles; the same acid is the final product of the action of water on the ether solution. The action of water proceeds rather more rapidly than in case of triphosphonitrilic chloride, but many days are required for complete decomposition. The small amount of material at present in my possession made it unadvisable to attempt to isolate any of the chlorhydrines, of which seven are theoretically possible.

Tetrametaphosphimic acid, $P_4N_4O_8H_8+2H_2O$, will be described in a separate section. It may be remarked here preliminarily that it has highly characteristic properties, is highly crystalline, very difficultly soluble in cold water, and much less soluble in dilute acids; that it readily decomposes soluble chlorides, nitrates, and sulphates, and gives three series of salts, in which, respectively, one-fourth, one half, and all the hydrogen is replaced by metal; many of these show characteristic forms. The free acid far surpasses the metaphosphoric acids in stability, and may be boiled for hours with nitric acid or aqua regia without much decomposition.

Tetraphosphonitrilic chloride is readily extracted from its ethereal solution by aqueous ammonia, the ammoniacal solution giving tetrametaphosphimic acid on warming with hydrochloric acid. No clear evidence of the formation of chloramides has yet been observed.

Oily phosphonitrilic chloride.—This substance, obtained from the residues as above stated, is possibly a mixture. It is scarcely volatile without decomposition, not volatile with steam, and not acted on by water, except in ethereal solution, when a moderately soluble phosphimic acid is slowly formed, which crystallizes in needles, and decomposes on warming with water into tetrametaphosphimic acid and ammonium phosphate. The analysis gave:

	Calculated for $(PNCl_2)_x$.	Found.
P	26.77	26.73
N	12.11	12.09
Cl	61.12	61.89

P : N : Cl = 1 : 1 : 2.03.

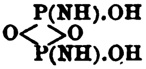
2. ON TRIMETAPHOSPHIMIC ACID AND ITS DECOMPOSITION PRODUCTS.

In the preceding section of this paper I mentioned, by way of preliminary notice, that Liebig's chloronitride, $P_3N_3Cl_6$, by appropriate treatment gives an acid, $P_3N_3O_6H_6$, to which I gave the name trimetaphosphimic acid. The object of the present section is to describe in detail the properties and decomposition products of this, the third member of the metaphosphimic-acid series.

In the preliminary notice a metaphosphimic acid was defined as a metaphosphoric acid $(PO_3H)_n$, in which one-third of the oxygen is replaced by an equivalent of imide groups, NH, i. e., $(PNO_2H_2)_n$. It was further pointed out that for each acid of this formula, with the exception of the simplest, at least four forms are theoretically possible, two of which are direct substitution products of the corresponding metaphosphoric acid, containing a nucleus consisting of phosphorus atoms united by oxygen, the other two belonging to a different type, in which the phosphorus atoms are united by nitrogen. This was illustrated by the acid, $P_2N_2O_6H_6$, none of the forms of which, it is true, are as yet known with certainty:

(a)

Dimetaphosphoryl amide.



(b)

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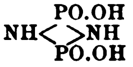


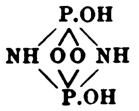
(c)

Dimetaphosphimic acid.

(d)

Diphosphonitrilic acid.

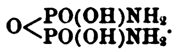
A fifth form might be added:



containing at the same time both the metaphosphoric and the metaphosphimic nucleus.

Schiff[1] described a body to which he gave the name phosphaminsæure, formed by acting on phosphorus pentoxide with dry ammonia, and which, according to his analyses, has the formula PNO_2H_2.[2] According to Gladstone and Holmes,[3] Schiff's acid is probably a mixture of pyrophosphodiamic and metaphosphoric acids. As Schiff failed to publish nitrogen determinations for his salts, it still remains a question whether a metaphosphimic acid can be produced in this way.

Gladstone, who was the first to devote much attention to phosphorus chloronitride, obtained from it by the action of aqueous ether and of alcoholic alkalies[4] an acid which he first called deutazophosphoric acid and later pyrophosphodiamic acid, and to which he gave the formula $P_2N_2O_5H_6$, regarding it as the diamide of pyrophosphoric acid.[5]



$$O{<}\begin{matrix}PO(OH)NH_2\\PO(OH)NH_2\end{matrix}.$$

While I am not prepared to deny positively the correctness of the formula deduced by Gladstone, and to assert that no such acid can be obtained in this way from phosphorus chloronitride, yet the facts as stated by him are capable of another interpretation, namely, that his acid is not the diamide of pyrophosphoric acid, but trimetaphosphimic acid.

It will be seen that

$$\underset{\text{Pyrophosphodiamate,}}{P_2N_2O_5H_4M'_2} = P_2N_2O_4H_2M'_2 + H_2O,$$

the latter being identical in empirical composition with $P_3N_3O_6H_3M'_3 + 1\frac{1}{2}H_2O$, i. e., a trimetaphosphimate with $1\frac{1}{2}H_2O$. Hence the latter, if containing this amount of water, might be mistaken for a pyrophosphodiamate. The only salts made by Gladstone directly from the chloride, $P_3N_3Cl_6$, were the silver and barium salts; the others were made from a supposed pyrophosphodiamate obtained from phosphorus oxychloride and ammonia, and there is no proof in Gladstone's papers of the identity of the acids from both sources. His figures for the

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[1] Ann. Chem. (Liebig), Vol. CIII, 1887, p. 168.

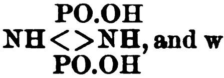
[2] I have elsewhere pointed out (Amer. Chem. Jour., Vol. XV, p. 198) that Schiff's acid has been erroneously described in some of the reference books as amidophosphoric acid, a body which I was the first to obtain.

[3] Jour. Chem. Soc. London, [2], Vol. II, pp. 229, 233, 235.

[4] Quart. Jour. Chem. Soc. London, Vol. III, pp. 135, 354; Ann. Chem. (Liebig), Vol. LXXVI, p. 79; Vol. LXXVII, p. 315; Jour. Chem. Soc. London, [2], Vol. II, p. 231.

[5] Jour. Chem. Soc. London, [2], Vol. VI, p. 69.

barium salt were, as he admits, not satisfactory, while the analyses of the silver salt were made with a crude preparation, for the purity of which there is no guaranty. I have myself found that barium trimetaphosphimate varies considerably in composition, contains water, and is hygroscopic. Sodium trimetaphosphimate is the only well-defined substance I have been able to obtain by decomposing the chloronitride by alcoholic soda, and the salt is so characteristic as hardly to be mistaken. It seems quite possible, therefore, that Gladstone actually had crude trimetaphosphimic acid in hand and failed to recognize its true nature only because of the unfortunate selection of salts which are amorphous, hydrated, and difficult to obtain pure.

In a paper of much later date Mente[1] described several acids obtained by the successive action of ammonium carbamate and water on phosphorus oxychloride. Among them is one to which he gave the name diimidodiphosphoric acid and the formula  $NH\overset{PO.OH}{\underset{PO.OH}{<>}}NH$, and which he regards as identical with Gladstone's pyrophosphodiamic acid. If Mente's formula is correct, it is the second or dimetaphosphimic acid. I have been unable to repeat Mente's work, and his data are too meager to admit of a positive conclusion, either as to its molecular weight or even its empirical composition, but it appears not to be identical with trimetaphosphimic acid.

Constitution of trimetaphosphimic acid.—Although trimetaphosphimic acid is an uncrystallizable and unstable body, it forms stable salts, several of which crystallize in characteristic forms. Three atoms of hydrogen are replaceable by alkali metals, while silver is able to replace either 3 or 6. The following are the most noteworthy:

$P_3N_3O_6H_3Na_3+4H_2O$—Rhombic prisms.
$P_3N_3O_6H_3Na_3+H_2O$—Slender prisms.
$P_3N_3O_6H_3(NH_4)_3+H_2O$—Scales.
$P_3N_3O_6H_3NaBa+1\frac{1}{2}H_2O$—Rhombohedra.
$P_3N_3O_6H_3Ag_3$—Monoclinic prisms.
$PN_3O_6Ag_6$—Two forms, white and red.

The first, third, and fifth serve to identify the acid. The tertiary silver salt, being anhydrous and easily obtained pure, establishes its empirical formula. Those salts which contain water of crystallization do not lose it completely at any temperature short of decomposition, leaving open the question whether the acid may not have the formula $P_3N_3O_7H_8$.

The constitution of trimetaphosphimic acid depends on that of the chloronitride $P_3N_3Cl_6$. The structural formula of the latter has not yet been definitely established, but the following data are available. It is reasonably certain that in the chloronitride phosphorus atoms are united by nitrogen atoms. Its formation from phosphorus pentachlo-

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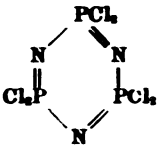
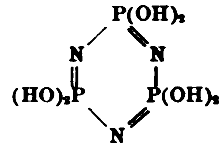
[1] Ann. Chem. (Liebig), Vol. CCXLVII, 1888, pp. 239, 244.

ride and ammonia is best explained on this assumption, as is its decomposition into orthophosphoric acid and ammonia. If phosphorus were united to phosphorus and nitrogen to nitrogen, the formation of reducing phosphoric acids or of hydrazine might be expected. Neither is it likely that chlorine is united to nitrogen, for in this case hydroxylamine might be expected to result. Several structural formulas are possible which meet this requirement, the simplest being that in which the nucleus consists of a symmetrical ring of 3 phosphorus and 3 nitrogen atoms:



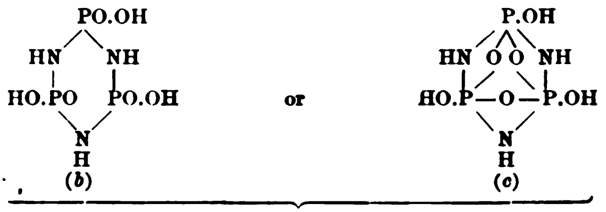
or a similar one with diagonal or "centric" union.

Direct replacement of chlorine by hydroxyl would then give



(a)
Triphosphonitrilic acid.

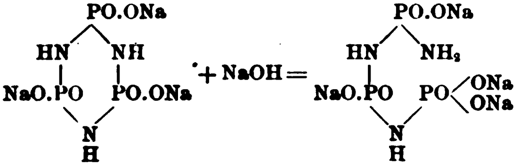
The labile nature of the hydrogen atoms in nitrogenous bodies, as observed in many organic compounds, makes it by no means improbable that an acid of this form may of itself, or under the influence of reagents, undergo transformation into the tautomeric form:



(b) (c)

Trimetaphosphimic acid.

An acid of the form (*a*) may be expected to give two sodium salts in which, respectively, 3 and 6 atoms of hydrogen are replaced. A salt with 6 atoms of sodium can not be produced, however, by any method which I have tried. The only salt besides the ordinary one with 3 atoms of sodium is one with 4 atoms, and this is formed in the presence of a large excess of caustic soda; it is very unstable and is reconverted into the 3-atom salt by repeated precipitation from aqueous solution by alcohol. It is not obvious why an acid of the form (*a*) should give such a salt. If we assume that (*b*) represents the correct formula, and that the acid is the symmetrical inner anhydrid or lactam of an open chain acid, we may regard this salt as being formed by addition, thus:



the latter being a salt of amido-diimidotriphosphoric acid.[1] Unfortunately I have been unable to prove this with certainty. A silver salt of the composition $P_3N_3O_7H_4Ag_4$ would render it extremely probable, as all silver salts of phosphorus nitrogen acids hitherto observed are free from crystal water. A salt with 4 atoms of silver can be obtained from the above 4-atom sodium salt, but it is very unstable, and its composition does not agree with sufficient sharpness with that of the cyclic or open chain form to establish either formula definitely.

I am therefore inclined to give preference to formula (*b*). It seems likely, however, that salts of triphosphonitrilic acid may also exist. The hexa-silver salt has been observed in two well-defined forms, as well as a third, possibly intermediate one. One of these is white, amorphous, and soluble in ammonium nitrate. It is easily converted into the other of identical composition, which is red, crystalline, and insoluble in the same reagent. The colorless salt probably contains silver united to oxygen only, while in the other one-half is united to nitrogen.

Decomposition products of trimetaphosphimic acid.—An aqueous solution of trimetaphosphimic acid, or of one of its salts acidified with one of the stronger mineral acids, decomposes slowly in the cold, rapidly on heating, the ultimate products being orthophosphoric acid and ammonia. If, however, the action be limited, there results a mixture of intermediate acids. The analysis of this mixture, which involved many experimental difficulties, proved the presence of the following:

1. Unchanged trimetaphosphimic acid, $P_3N_3O_6H_6$.
2. Diimidotriphosphoric acid, $P_3N_2O_8H_7$.
3. Imidodiphosphoric acid,[2] $P_2NO_6H_5$.
4. Pyrophosphoric acid, $P_2O_7H_4$.
5. Orthophosphoric acid, PO_4H_3.

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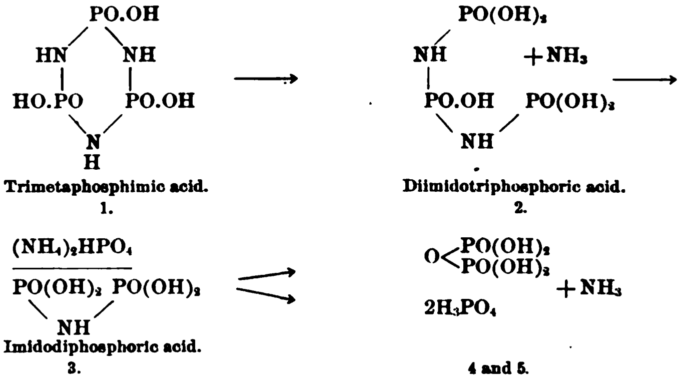
[1] The acids $PO(OH)_2.O.PO(OH)_2$ and $PO(OH)_2.O.PO(OH).O.PO(OH)_2$ being frequently designated as di- and triphosphoric acid, I call those in which the linking oxygen is replaced by imide, NH, imido-di- and diimidotriphosphoric acid.

[2] This acid has the same composition and is probably identical with Gladstone's azophosphoric or pyrophosphamic acid. Jour. Chem. Soc. London [2], Vol. VI, p. 66, etc.

Assuming formula (*b*) for trimetaphosphimic acid, its decomposition would be thus represented:



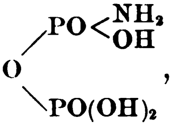
Trimetaphosphimic acid. 1.

Diimidotriphosphoric acid. 2.

Imidodiphosphoric acid. 3.

4 and 5.

The second acid is important as a connecting link, proving that trimetaphosphimic acid actually has the triple formula $(PNO_2H_2)_3$. Most remarkable is the formation of pyrophosphoric acid, which occurs directly from imidodiphosphoric acid. The facts are these: If sodium imidodiphosphate be weakly acidified with acetic acid and boiled from five to ten minutes, not more than 15 per cent is converted into pyrophosphoric acid and the remainder into orthophosphoric acid. Control experiments with sodium pyrophosphate showed that under the same conditions but a small portion is converted into orthophosphoric acid, 90 per cent of the pyrophosphate being recovered. The pyrophosphoric acid is therefore not an intermediate product, but the imidodiphosphate is converted for the greater part directly into orthophosphoric acid, and in a much less degree into pyrophosphoric acid.

The above formula of imidodiphosphoric acid containing the group P—NH—P, follows directly from that of trimetaphosphimic acid. In view of the ease with which the condensed phosphoric acids split up in aqueous solution into orthophosphoric acid, while the reverse never occurs, it is difficult to see how the action of water or acids on a body of the assumed formula could give pyrophosphoric acid. If we adopt Gladstone's formula[1]  $\mathrm{O}\begin{matrix}\diagup\mathrm{PO}<^{\mathrm{NH_2}}_{\mathrm{OH}}\\ \diagdown\mathrm{PO(OH)_2}\end{matrix}$, we can explain the formation of pyrophosphoric acid, but must at the same time assume that somewhere in the series the group P—N—P has been converted into P—O—P, for in the chloronitride, $P_3N_3Cl_6$, phosphorus can be united only by nitrogen. If the acid were really the amide of pyrophosphoric acid, boiling with acetic acid would first convert it into pyrophosphoric acid which, as above shown, is fairly stable under the observed

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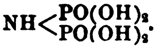
[1] Jour. Chem. Soc. London, [2], Vol. VI, p. 70.

conditions, and should be found present to the extent of at least 90 per cent instead of only 15 per cent. On this ground, it seems to me, we must reject the amidopyrophosphoric formula, and regard the body as imidodiphosphoric acid,



$$\mathrm{NH}<\begin{matrix}\mathrm{PO(OH)_2}\\ \mathrm{PO(OH)_2}\end{matrix}.$$

This formula does not account for the pyrophosphoric acid. We may, perhaps, conceive that owing to the greater affinity of phosphorus for oxygen than for nitrogen, a group, $\mathrm{PO.(OH)_2}$, is able to change places with a hydroxylic hydrogen atom:

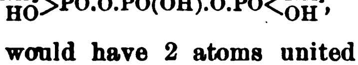
$$\begin{matrix}\mathrm{HO.PO.O{-}H}\\ |\\ \mathrm{HN{-}PO(OH)_2}\end{matrix} = \begin{matrix}\mathrm{HO.PO.O{-}PO(OH)_2}\\ |\\ \mathrm{HN{-}H}\end{matrix}$$

the latter, in common with other amido phosphoric acids, being unstable, and passing easily into pyrophosphoric acid. It may be noted that this transformation seems to be promoted by heat, apparently more pyrophosphoric acid being formed by decomposing trimetaphosphimic acid in hot than in cold solution.

The second acid of the series, diimidotriphosphoric acid, seems really to have the constitution,

$$\mathrm{PO(OH)_2.NH.PO(OH).NH.PO(OH)_2},$$

implied by the name. It forms an acid salt with 3, and a neutral salt with 5 atoms of silver, both of which are colorless. If it were a diamide of triphosphoric acid,



$$\begin{matrix}\mathrm{NH_2}\\ \mathrm{HO}\end{matrix}>\mathrm{PO.O.PO(OH).O.PO}<\begin{matrix}\mathrm{NH_2}\\ \mathrm{OH}\end{matrix},$$

the penta-silver salt would have 2 atoms united to nitrogen, and such a salt, to judge from all phosphorus-nitrogen salts, where this is known to be the case, would be distinctly colored.

Still another intermediate acid is possible, preceding imidodiphosphoric acid, viz, amidoimidodiphosphoric acid,

$$\begin{matrix}\mathrm{NH_2}\\ \mathrm{HO}\end{matrix}>\mathrm{PO.NH.PO(OH)_2}.$$

I have been unable to detect this acid thus far, but the too high percentage of nitrogen invariably found in imperfectly purified imidodiphosphoric acid, may be due to the presence of small amounts of this body.

In giving formulas to these bodies, I wish to be understood as using them with full appreciation of their uncertainty. A much more exhaustive study is necessary before they can be regarded as established as firmly as those of many organic compounds. There are several directions in which such a study might be of value. Besides the question of tautomerism, the stereochemistry of nitrogen might be attacked with profit from this side. The analogy of nitrogen and phosphorus suggests the possibility of steric phenomena being shown by the latter also. The formula (*b*) suggested for trimetaphosphimic acid, for example, may imply a cis- and cis-trans-form depending on the posi tion of the hydroxyls as well as of the imide hydrogen atoms; in short, quite a number of stereo-isomers may be conceived. I have thus far sought in vain for indications of the existence of such forms.

EXPERIMENTAL PART.

Analytical methods.—Salts of trimetaphosphimic acid and derived bodies are easily decomposed by fusion with sodium carbonate. As the process involves oxidation it is essential to keep the mass in a state of fusion for some time with access of air. Salts of silver of other easily reducible metals and those in which it is desired to determine alkali or nitrogen must be decomposed by strong sulphuric acid. The substance, contained in a platinum crucible, is first moistened with dilute, and then covered with 4 or 5 cubic centimeters strong sulphuric acid, and the covered crucible heated to fuming for an hour in a radiator, care being taken that the fumes do not escape. In determining alkali metal, the resulting phosphoric acid may be conveniently removed by the ferric chloride-acetate method. As the water of crystallization can not be completely expelled by heat without partial decomposition, it is best determined, together with the hydrogen of the salt proper, by combustion. This is conveniently carried out in a short combustion tube with a 10-centimeter spiral of oxidized copper gauze, the substance, contained in a boat, being covered with fused potassium bichromate. As nitrous fumes are formed in abundance, the usual precautions must be taken. In the following, where more than one determination is given, the numbers always refer to different preparations.

Preparation of trimetaphosphimic acid.—The sodium salt affords the starting material for all preparations of trimetaphosphimic acid. It may be obtained by saponifying triphosphonitrilic chloride by alcoholic soda, but with much loss, owing to the formation of ethers and other substances of unknown nature. The chloride, as observed by Liebig and by Gladstone, is practically unacted on either by water or anhydrous ether, but, as I have already pointed out elsewhere, its decomposition may readily be effected by shaking its ethereal solution protractedly with water, whereby intimate contact is secured. Decomposition by ether and water alone, however, results in much loss, as the liberated hydrochloric acid rapidly decomposes trimetaphosphimic acid. The following method is perfectly satisfactory and gives practically the theoretical yield.

Thirty grams of the chloride are dissolved in 150 cubic centimeters ether free from alcohol, and the solution gently agitated with a solution of 110 grams crystallized sodium acetate in 200 cubic centimeters water, the agitation being conveniently effected by slowly rotating with a small turbine. After about fifteen hours, well-formed crystals of sodium salt begin to appear, and about seventy or eighty hours are required for complete decomposition. This point is best observed by evaporating a few drops of the ether and taking up the residue with water, any undecomposed chloride remaining undissolved. It is best to continue the agitation for a short time longer in order to decompose the chlorhydrines, which are always formed as intermediate products. At the end of the operation nearly all the sodium salt has crystallized out, being almost insoluble in the strong salt solution; a further small amount can be recovered by mixing the solution with alcohol. After washing with 50 per cent alcohol, the salt is pure enough for most purposes, but may be redissolved in water and precipitated by gradual addition of alcohol.

The same salt also results by decomposing triphosphonitrilic tetrachlorhydrine with soda. It exists in two forms, apparently differing only in the amount of crystal water, the α-salt being formed at ordinary temperatures, the β-salt only above 80°.

α-Sodium trimetaphosphimate, $P_3N_3O_6H_3Na_3 + 4H_2O$.—The air-dried salt, prepared as above, gave the following figures:

	Calculated for $P_3N_3O_6H_3Na_3 + 4H_2O$.	Found.	
		1.	2.
P	24.79	24.74	24.82
N	11.22	11.26	....
Na	18.41	18.45	18.43
H	2.94	3.05	2.97

1. P:N:Na:H = 3:3.02:3.01:11.47.
2. P:Na:H = 3:2.97:11.

It loses weight slowly in vacuo, and 3 molecules of water are given off on long heating at 100°. After five hours at 100° the loss was:

	Calculated for $3H_2O$.	Found.
Loss	14.38	14.05

This is one of the most characteristic salts of trimetaphosphimic acid. It forms brittle orthorhombic prisms, usually about 1–2 millimeters across, of which fig. 1 represents the most common form.

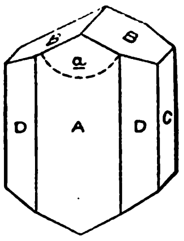


Fig. 1.

$A = \infty P \bar{\infty}$.
$B = P \breve{\infty}$.

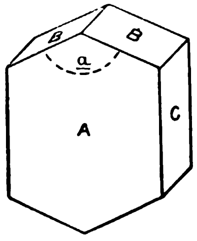


Fig. 2.

$C = \breve{\infty} P \breve{\infty}$.
$D = \infty P$.

The angle *a*, measured roughly under the microscope, is about 130°. No other faces are ever observed, and D is frequently lacking, giving the form shown in fig. 2, which is often seen to be elongated in the direction of any one of the axes. They are especially well developed when slowly thrown down by acetic acid and alcohol from alkaline solution. When formed by rapid addition of alcohol in large excess they tend to elongation in the direction of the principal axis, being often acicular, often long, flat prisms with imperfectly developed ends.

At 20°, 100 parts water dissolve 18.3 parts; in hot water it is much more soluble, and from its hot solution it crystallizes but slowly; the larger crystals dissolve in hot water with a crepitating sound. The reaction toward litmus is neutral. On rapidly heating the dry salt it gives off water and later ammonia, and fuses to a clear glass. It is but slowly decomposed by boiling with water; after three hours heating traces of phosphoric and imidodiphosphoric acid were shown by magnesia mixture. Alkalies do not cause the evolution of any appreciable quantity of ammonia, even when hot; apparently, however, their very long-continued action is attended with decomposition.

β-Sodium trimetaphosphimate, $P_3N_3O_6H_3Na_3+H_2O$.—This form is deposited when the solution has a temperature of 80° or higher. It was obtained—

(1) By boiling the solid α-salt under a strong solution of sodium nitrite (analysis 1).

(2) By slowly adding boiling alcohol to a boiling solution of the α-salt (analysis 2).

(3) By pouring a boiling solution of the α-salt into a boiling 25 per cent solution of sodium acetate.

Doubtless other sodium salts would serve equally well, provided their hot solutions are sufficiently strong to throw it out.

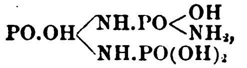
The salt lost nothing at 100° and gave:

	Calculated for $P_3N_3O_6H_3Na_3+H_2O$.	Found.	
		1.	2.
P	28.97	28.31	28.97
N	13.11	....	13.08
Na	21.51	21.86	21.19

1. P : Na = 3 : 3.12.
2. P : N : Na = 3 : 2.99 : 2.90.

This modification of the sodium salt forms needles, which, under the microscope, are seen to consist of flat prisms terminating in points; the terminal angles are of two kinds, one rather more, the other rather less than 90°; frequently both of these may be observed at opposite ends of the same crystal. Often, too, the crystals are cut off obliquely, owing to the development of but one terminal plane, in which case the terminal angles are respectively rather more and rather less than 45°. In general properties it resembles the α-salt, which it gives when reprecipitated from cold solution; whether the difference consists merely in the amount of crystal water, or whether it is a chemically distinct body can not be decided at present.

Tetra-sodium salt (*sodium amido-diimidotriphosphate*), $P_3N_3O_7H_4Na_4 + H_2O$.—As pointed out in the introduction, this is best regarded as the neutral salt of an open chain acid,



$$\mathrm{PO.OH}\Big\langle\begin{matrix}\mathrm{NH.PO}\Big\langle\begin{matrix}\mathrm{OH}\\ \mathrm{NH_3},\end{matrix}\\ \mathrm{NH.PO(OH)_2}\end{matrix}$$

of which trimetaphosphimic acid is the inner anhydride. As positive proof of this can not be adduced at present, I have preferred to place it among the trimetaphosphimates.

On dissolving sodium trimetaphosphimate in an excess of caustic soda, concentrating and allowing to cool, the salt crystallizes in long brittle needles (analysis 1). On adding alcohol to a caustic soda solution of sodium trimetaphosphimate (which need not have been heated), it is thrown out as a sirup which crystallizes, slowly if left to itself, at once on adding a fragment of previously prepared salt, to a mass of delicate colorless needles (analysis 2). These must be washed with alcohol containing a little caustic soda in solution, strongly pressed out and dried out of contact with carbon dioxide. It contains a large amount of crystal water, which it loses, with the exception of the last molecule, on drying in vacuo; the exact amount could not be determined. The substance dried in vacuo lost nothing at 100° and gave:

	Calculated for $P_3N_3O_7H_4Na_4 + H_2O$.	Found.	
		1.	2.
P	25.76	25.34	25.60
N	11.66	....	11.96
Na	25.51	25.60	25.76

1. P : Na = 3 : 4.08.
2. P : N : Na = 3 : 1.09 : 4.06.

This salt is very unstable, being decomposed even in the solid state by carbon dioxide. From its cold aqueous solution alcohol precipitates a mixture of unchanged salt and α-sodium trimetaphosphimate, a few reprecipitations converting it completely into the latter and free alkali. Its behavior toward silver nitrate is described under the silver trimetaphosphimates.

Salts with less than 3 or more than 4 atoms of sodium could not be obtained.

Potassium trimetaphosphimate, $P_3N_3O_6H_3K_3$.—A solution of this salt was obtained by decomposing the barium salt with potassium sulphate; on evaporation a transparent, glassy mass resulted. Alcohol precipitated it as a sirup, which on repeated treatment with absolute alcohol was converted into indistinct crystals. It was not further examined.

Ammonium trimetaphosphimate, $P_3N_3O_6H_3(NH_4)_3 + H_2O$.—A solution of this salt was obtained by double decomposition from the barium and silver salts and by neutralizing the free acid with ammonia. It loses ammonia on evaporation and leaves a transparent amorphous residue. Its solution, treated with alcohol, gives a deposit of large and beautiful pearly scales, which are characteristic. As these form even in the presence of a large excess of ammonia it appears that a body analogous to the tetra-sodium salt can not be thus formed.

The air-dried substance gave:

	Calculated for $P_3N_3O_6H_3(NH_4)_3 + H_2O$.	Found.
P	30.38	30.19
N	27.50	27.03

Magnesium trimetaphosphimate, $(P_3N_3O_6H_3)_2Mg_3$(?).—Strong solutions of sodium trimetaphosphimate and magnesium chloride give no precipitate, even on boiling. A solution of the magnesium salt may be obtained by double decomposition. From this alcohol throws down an amorphous flocculent precipitate and it leaves a soluble transparent residue on evaporating. On boiling the solution is slowly decomposed.

A mixture of a not too dilute solution of sodium salt with an excess of a strong solution of magnesium acetate remains clear, but is precipitated by acetic acid; on adding a little water this precipitate redissolves, reappears on heating, and redissolves on cooling. The nature of these precipitates has not been investigated. With more water the solution remains clear on short boiling, but on continued heating a crystalline precipitate forms which examination shows to consist of magnesium pyrophosphate and imidodiphosphate, orthophosphoric acid remaining in solution.

The fact that trimetaphosphimic acid is not precipitated in the cold by ammoniacal magnesia mixture affords a valuable means of separating it from some of its decomposition products.

Barium trimetaphosphimates.—Much time was spent in studying these salts, until it was found that they are devoid of characteristic properties, and that they are of exceedingly varying composition. Both neutral and basic salts exist, and there is a strong tendency to form double salts. The tendency to form complex salts is so strong that when barium nitrate, chloride, or acetate is used as the precipitant, the product is invariably contaminated by these. It has proved impossible to obtain a single satisfactory analysis, but the following data may be mentioned:

A salt obtained by decomposing an ethereal solution of phosphorus chloronitride with excess of baryta water consisted of a pulverulent, indistinctly crystalline substance for which the ratio P : Ba = 6 : 4.48 was found, while the calculated ratio for neutral salt is 6 : 3.

The potassium salt, precipitated by ammoniacal barium chloride, gave a preparation in which P : Ba = 6 : 3.68.

Triphosphonitrilic tetrachlorhydrine gave a clear solution with ammonia and barium chloride; on boiling a granular precipitate resulted (analysis 1).

Ethereal chloronitride and barium acetate solution gave a preparation from which the figures under analysis 2 were obtained.

A precipitate from the potassium salt and neutral barium chloride gave the results recorded under analysis 3.

	Calculated for $(P_3N_3O_6H_3)_2Ba_3 + 4H_2O$.	Calculated for $(P_3N_3O_6H_3)_2Ba_3 + 6H_2O$.	Found.		
			1.	2.	3.
P	19.89	19.16	19.91	20.86	20.46
Ba	43.96	42.35	41.75	41.91	43.79

1. P : Ba = 6 : 2.85. Dried at 100°.
2. P : Ba = 6 : 2.73. Dried in vacuo.
3. P : Ba = 6 : 2.91. Dried at 100°.

The neutral salt is slightly soluble in water and easily in a solution of ammonium chloride; on boiling the latter it is partially reprecipitated. It also dissolves readily in a strong solution of sodium chloride, and, on warming, the barium sodium salt is precipitated.

Barium sodium trimetaphosphimate, $P_3N_3O_6H_3NaBa + 1\frac{1}{2}(?)H_2O$.—This salt is almost insoluble in water, and forms a heavy, crystalline powder, which is seen under the microscope to consist of spherical aggregates with many rhombic facets, or occasionally of single minute crystals, apparently rhombohedra. The ordinary amorphous barium salt is invariably formed by precipitating any soluble trimetaphosphimate with a barium salt in the cold, but if the chloride or other salts of sodium be present in sufficient quantity, this passes into the crystalline barium sodium salt, at once on heating, or in the cold after a period varying from a few minutes to several hours. The latter also forms at once on precipitating in hot solutions. It was also obtained by decomposing an ethereal solution of chloronitride (1 molecular weight) with a solution of barium acetate (1 molecular weight) and sodium acetate (9 molecular weights). As is so common with salts of barium, this tends to "carry down" a considerable amount of the precipitant. A preparation made by the last method mentioned contained 0.49 per cent chlorine, corresponding to a contamination of 1.44 per cent barium chloride. After making correction for this the figures under analysis 3 were obtained, which approximate closely to the theoretical.[1] The excess of barium in analyses 1 and 2 is accounted for in the same manner. Possibly the difficulty is due to the presence of half dissociated barium ions (e. g. +BaCl) in the solution.

The substance lost but little at 100° and gave:

	Calculated for $P_3N_3O_6H_3NaBa+1\frac{1}{2}H_2O$.	Found.		
		1.	2.	3.
P	22.09	21.50	21.86	21.99
N	9.99	9.91	....	....
Na	5.47	....	5.56	5.53
Ba	32.56	35.67	34.22	32.86
H	1.43	....	....	1.32

1. P : N : Ba = 3 : 3.05 : 1.12.
2. P : Na : Ba = 3 : 1.03 : 1.06.
3. P : Na : Ba : H = 3 : 1.02 : 1.01 : 5.58.

Similar salts containing potassium or ammonium could not be obtained. A barium silver salt consisting of microscopic spherules was obtained by adding silver nitrate to a solution of the neutral barium salt in ammonium nitrate; a qualitative examination showed the presence of barium and silver.

Tri-silver trimetaphosphimate, $P_3N_3O_6Ag_3$.—This is the most important salt obtained, on account of its highly characteristic crystalline form, and because it is anhydrous and easily prepared pure, thereby establishing the empirical composition of trimetaphosphimic acid. As those salts which contain crystal water do not lose it completely at a temperature short of decompositon, we should otherwise be unable to decide between the formulas $P_3N_3O_6H_6$ and $P_3N_3O_7H_8$. For comparison the theoretical figures for a silver salt of both of these are given.

The salt may be prepared by precipitating a cold dilute solution (1–50) of the sodium salt by silver nitrate, when it is thrown down at once in the form of colorless elongated microscopic plates, terminated by an angle of 78° (analyses 1–4). Much better crystals are obtained if the solution of the sodium salt be acidified with several equivalents of nitric acid and the silver nitrate added slowly, finally in large excess. In this way the crystallization is made to extend over a considerable time, but the precipitation is never complete (analysis 5). Thus formed the crystals are usually very well developed, though seldom over 2 millimeters long, and consist of thick, monoclinic plates of the forms represented in figs. 3 and 4, the latter resulting when the crystallization extends

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[1] Richards has pointed out the necessity of making a similar correction in determining sulphuric acid as barium sulphate. Zeitschr. anorg. Chem., Vol. VIII, p. 413.

over several hours. No other faces are ever observed, and the angle *a* (between the edges) measured under the microscope is very nearly 78°.

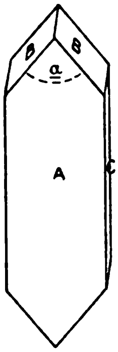

Fig. 3.

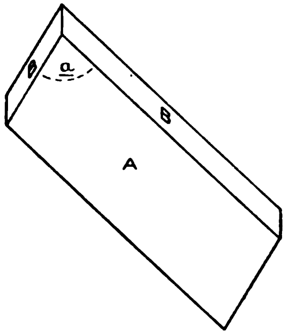

Fig. 4.

$A = \infty P \bar{\infty}$. $B = P \breve{\infty}$. $C = \infty P \breve{\infty}$.

The air-dried salt lost nothing at 100° and gave:

	Calculated for $P_3N_3O_6H_3Ag_3$.	Calculated for $P_3N_3O_7H_5Ag_3$.	Found.					
			1.	2.	3.	4.	5.	6.
P	16.68	16.16	16.50	16.70	16.74	16.64	....	15.71
N	7.55	7.31	....	7.53	7.67	....	7.72	....
Ag	58.04	56.20	57.75	57.90	57.77	57.93	57.80	60.08
H	0.54	0.87	....	0.62	....	....	....	....

1. P : Ag = 3 : 3.02.
2. P : N : Ag : H = 3 : 2.99 : 2.99 : 3.47.
3. P : N : Ag = 3 : 2.98 : 3.04.
4. P : Ag = 3 : 3.
5. N : Ag = 3 : 3.
6. P : Ag = 3 : 3.3

The salt is insoluble in water, easily soluble in ammonia, and somewhat difficultly in dilute nitric acid. It is not affected by light, but on boiling under water it becomes somewhat yellow, owing to the formation of a superficial coating of the 6-atom salt and the liberation of free acid, the decomposition products of which can be detected in the liquid. If free from silver nitrate, caustic soda does not discolor it, even on boiling. On heating it swells up, gives off ammonia, and fuses to a mass which contains metallic silver. In order to ascertain if it is actually precipitated in the anhydrous form, or if it contains water which is given off on standing, a freshly precipitated sample was washed with alcohol and ether, pressed out, and at once weighed; it lost nothing at 100°, indicating that even at the moment of formation it is anhydrous. Precipitation from boiling solution seems to have no influence on its composition; if, however, the solution of the sodium salt be added to a large excess of a solution of silver nitrate, the resulting precipitate, though white, is amorphous and contains much too high a percentage of silver (analysis 6), probably indicating an admixture of a more basic salt.

If tri-silver trimetaphosphimate be heated in a current of dry air at a temperature rising gradually from 200° to 260°, very nearly one-third of the nitrogen is given off as ammonia:

	Calculated for NH_3.	Found.
Loss	3.05	2.86

The product is no longer completely soluble in dilute acid. Alternate treatment with sodium chloride and ammonia extracts the silver and an acid which gives an amorphous precipitate with magnesium nitrate mixture. A considerable white residue remains in the form of pseudomorphs of the original substance, which is insoluble in ammonia, and soluble in hydrochloric acid only on boiling.

Salt with 4 atoms of silver, $P_3N_3O_6H_2Ag_4$ or $P_3N_3O_7H_4Ag_4$.—If silver nitrate be added slowly to a solution of the 4-atom sodium salt (sodium amidodiimidotriphosphate), each drop produces a white precipitate, which, on stirring, turns yellowish, in presence of an excess of sodium salt; when the latter is used up and an excess of silver nitrate has been added, it again becomes white. If, on the contrary, the sodium salt be added to the silver nitrate, each drop gives a yellow precipitate, turning white on stirring, and remaining so as long as an excess of silver is present. This white amorphous salt is decomposed by washing with pure water, turning yellow, while trimetaphosphimic acid goes into solution. The change may be represented thus:

$$3P_3N_3O_7H_4Ag_4 = 2P_3N_3O_7H_2Ag_6 + P_3N_3O_6H_6 + H_2O.$$

Silver nitrate prevents this change; the precipitate must therefore be washed with 1 per cent aqueous solution of silver nitrate, then with 1 per cent alcoholic solution of the same, and finally with ether. On pressing and drying, it then remains colorless. Preparations made in this manner gave the following results after drying at 100°, at which temperature the salt remains white:

	Calculated for $P_3N_3O_6H_2Ag_4$.	Calculated for $P_3N_3O_7H_4Ag_4$.	Found.		
			1.	2.	3.
P	14.01	13.63	13.32	13.70	13.29
Ag	64.92	63.22	65.79	64.71	65.89

1. P : Ag = 3 : 4.26.
2. P : Ag = 3 : 4.07.
3. P : Ag = 3 : 4.28.

Unfortunately, the figures do not admit of a positive decision as to the formula, but the extreme instability of the salt, as compared with the others, may indicate an acid of different nature from trimetaphosphimic acid.

If this salt be allowed to stand for a day or two under pure water, it is converted into a mixture of tertiary silver trimetaphosphimate and a yellow crystalline salt with 6 atoms silver.

$$3P_3N_3O_7H_4Ag_4 = P_3N_3O_7H_2Ag_6 + 2P_3N_3O_6H_3Ag_3 + 2H_2O.$$

The same change occurs rapidly on boiling. Whatever may be the nature of the salt, this change is doubtless due to the tendency of the silver to wander to the nitrogen; silver nitrate, by opposing dissociation, prevents alteration.

Salts with 6 atoms of silver, $P_3N_3O_6Ag_6$ and perhaps $P_3N_3O_7H_2Ag_6$ also.—Equally unsatisfactory analytical results are given by the salts with 6 atoms of silver. The figures indicate the tendency to formation of salts with the ratio P:Ag=3:6, but the actual ratio only approximates to this, and it is impossible on the basis of the analyses alone to decide which of the formulas $P_3N_3O_6Ag_6$ and $P_3N_3O_7H_2Ag_6$ should be adopted in most cases. After many experiments I have been compelled to abandon for the present the attempt to obtain these substances in entirely satisfactory condition, and give the figures as actually obtained.[1]

If sodium trimetaphosphimate be added to an excess of an ammoniacal solution of silver nitrate,[2] or of a solution of silver oxide in ammonium nitrate,[3] a portion of the trimetaphosphimic acid is precipitated as a pure white voluminous and amorphous body, which, as analysis shows, contains approximately 6 atoms of silver. The precipitation is very incomplete, especially when ammoniacal silver nitrate is used, but in this case the substance contains very nearly 6 atoms of silver, while if the silver oxide solution be employed the percentage of silver is considerably too low.[4] Heated under the mother liquor it becomes yellowish, and becomes white again on cooling. After washing out (whereby it becomes yellowish) it dissolves quite readily in strong ammonium nitrate solution, but if boiled with less of the same, or less rapidly if heated with water alone, it is quickly converted into a heavy pulverulent substance. This, if highly magnified, is seen to consist of spherules or indistinct prisms, and has a color varying from orange to deep orange-red, usually the latter. This salt likewise contains 6 atoms of silver. The transformation is prevented by any silver nitrate in the solution, unless the effect of this is neutralized by a large quantity of ammonium nitrate.

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[1] See p. 146 of this bulletin for an explanation of these difficulties.

[2] Prepared by adding ammonia to silver nitrate solution till the brown precipitate just redissolves.

[3] Three grams silver oxide, 10 grams ammonium nitrate, and 50 cubic centimeters water.

[4] The filtrate, on evaporation over sulphuric acid, deposits an imperfectly crystalline substance, at first white, then yellow, which is probably identical with the yellow salt referred to below.

If a solution of sodium trimetaphosphimate, to which exactly 3 molecular weights caustic soda, or an excess of ammonia, have been added, be dropped into an excess of dilute silver nitrate, a light sulphur-yellow, voluminous, and amorphous precipitate is formed, which may be washed with cold water without change, and does not change color on drying. This likewise contains 6 atoms of silver, and is insoluble in ammonium nitrate. If boiled with a trace of silver nitrate it remains unchanged; but if boiled with pure water it changes slowly, or if sodium trimetaphosphimate or ammonium nitrate be present, in a few moments, into the same orange-red, crystalline powder above mentioned.[1] On one occasion a deep red crystalline powder was obtained, but the conditions for its formation could not be determined. The following figures resulted from the analyses of these salts, in every case dried at 100°:

	Calculated for $P_3N_3O_7H_2Ag_6$.	Calculated for $P_3N_3O_6Ag_6$.
P	10.39	10.59
Ag	72.21	73.69

WHITE SALT (AMORPHOUS).

	Found.			Remarks.
	Lowest.	Highest.	Mean.	
P	10.54	11.28	10.92	4 preparations.
Ag	71.04	71.93	71.58	Mean ratio P : Ag = 3 : 5.66.

YELLOW SALT (AMORPHOUS AND CRYSTALLINE).

P	10.23	10.65	10.44	7 preparations.
Ag	71.55	73.13	72.53	Mean ratio P : Ag = 3 : 5.99.

ORANGE-RED SALT (CRYSTALLINE).

P	10.69	10.91	10.81	5 preparations.
Ag	72.38	72.91	72.61	Mean ratio P : Ag = 3 : 5.79.

RED SALT (CRYSTALLINE).

P	....	....	10.65	1 preparation.
Ag	....	....	73.18	Ratio P : Ag = 3 : 5.93.

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[1] This is seen to crystallize from the liquid, so that temporary solution must take place.

Unsatisfactory as these figures are, they appear to indicate the existence of:

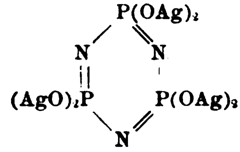
(1) A yellow salt, usually amorphous, occasionally crystalline, approximating in composition to $P_3N_3O_7H_2Ag_6$. As this is only formed in the cold from a trimetaphosphimate to which alkali has been added, it may be a salt of the supposed open-chain acid.

(2) A red crystalline salt of the formula $P_3N_3O_6Ag_6$.

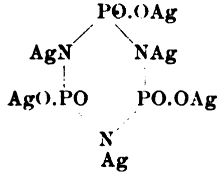
(3) A white amorphous salt of nearly the same composition.

The orange-red salt, invariably containing too little silver, and varying in depth of color, may be a mixture or an intermediate form.

As the white salt is formed only in the presence of silver ammonia compounds, and is quite soluble in ammonium nitrate, it is clearly different in nature from the others. Probably it contains silver united to oxygen only, while in the red salt one-half the metal is associated with nitrogen. We may regard them as salts of the two forms of trimetaphosphimic acid:



Hexa-silver triphosphonitrilate.



Hexa-silver trimetaphosphimate.

The action of silver nitrate in preventing the transformation may be ascribed to its opposing dissociation. No deep decomposition occurs during the transformation, as the ammoniacal solution is not precipitated by magnesia mixture, and sodium trimetaphosphimate is regenerated by treatment with sodium chloride and acetic acid.

Ferric trimetaphosphimates.—Gladstone[1] states that when pyrophosphodiamic acid is added to ferric sulphate, acidified with sulphuric acid, a clear solution results, which, on boiling, deposits white ferric pyrophosphamate, which is insoluble in acids but soluble in ammonia. The ferric trimetaphosphimates seem to vary considerably in composition and properties and present no characteristic features. The following points were noted: On adding ferric chloride to a moderately strong solution of sodium trimetaphosphimate an amorphous white precipitate forms which redissolves in an excess of the sodium salt, probably with formation of a ferric-sodium salt, but which becomes permanent on adding more ferric chloride. This is scarcely soluble in dilute hydrochloric acid, but readily soluble in ammonia with faint red color. Sodium hydroxide regenerates sodium salt. If, however, the solution of the sodium salt be dilute, no precipitate forms in the cold, even with an excess of ferric chloride, but on boiling, after acidifying,

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[1] Quart Jour. Chem. Soc. London, Vol. III, p. 135; Jour. Chem. Soc., London, [2], Vol. II, p. 229; [2], Vol. IV, p. 290; [2], Vol. VI, p. 67.

a white amorphous precipitate is produced, which, like the above, is nearly insoluble in dilute acid and easily soluble in ammonia and consists of trimetaphosphimate mixed with decomposition products.

The solubility of these salts in ammonia, which they show in common with other ferric amidophosphates and pyrophosphates, may be ascribed to the formation of complex ions containing iron; in other words, of ferri-trimetaphosphimic acids, analogous to ferri-oxalic acid[1] and similar bodies.

Free trimetaphosphimic acid.—Silver trimetaphosphimate, decomposed under cold water by hydrogen sulphide, gives a solution from which, when fresh, the characteristic salts may be prepared, and from which much alcohol gradually throws out an amorphous sticky mass. The solution, on evaporation in vacuo, leaves a transparent, gummy residue from which alkalies evolve much ammonia, and which, after redissolving, gives a precipitate with magnesium mixture, indicating partial decomposition. The acid seems therefore to be incapable of crystallization.

In marked distinction from metaphosphoric acid, trimetaphosphimic acid does not coagulate albumen.

DECOMPOSITION PRODUCTS OF TRIMETAPHOSPHIMIC ACID.

Orthophosphoric acid and ammonia are the ultimate products of the action of acids on trimetaphosphimic acid, as well as of the decomposition of the free acid alone in aqueous solution when heated or kept for a long time. I have, however, been able to isolate three well-marked intermediate bodies, viz:

Diimidotriphosphoric acid, $P_3N_2O_8H_7$;
Imidodiphosphoric acid, $P_2NO_6H_5$;
Pyrophosphoric acid, $P_2O_7H_4$.

If sodium trimetaphosphimate solution (1–15) be boiled with 2–3 molecular weights nitric acid, the transformation into ammonia and orthophosphoric acid is complete in about ten minutes, but on interrupting the boiling after three to four minutes and cooling, the presence of these products can be detected; the same change occurs slowly in the cold, many days being required for complete decomposition. From this solution silver nitrate throws down first the silver salt of unchanged trimetaphosphimic acid, then the others in the order named, and finally silver phosphate, which is most easily soluble in nitric acid.

Although these products were first detected in this way, many experiments have convinced me that it is not a practical method of separation. The separation by fractional precipitation is not sharp; the properties of trimetaphosphimic and diimidotriphosphoric acids are so similar and the stability of the latter so slight that the results are very unsatisfactory. In the absence of trimetaphosphimic acid, however, diimidotriphosphoric acid is readily separated from the later decomposition

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[1] See Rosenheim, Zeitschr. anorg. Chem., Vol. XI, p. 214, etc.

products. If, therefore, we have ascertained the time required for all the trimetaphosphimic acid to be decomposed under given conditions, while diimidotriphosphoric acid still remains, we can isolate the latter in a condition of purity. Since the latter is merely a transition product, the amount present at any time is small, and the actual yield is only about 10 per cent of the theoretical.

The following method leads to the desired result: 1 molecular weight α-sodium trimetaphosphimate is dissolved in 15 parts cold water, 3 molecular weights nitric acid (strength about 15 per cent) added, and the solution allowed to stand for seven days at the ordinary temperature. Enough ammonia is then added to give a faint odor and an excess of magnesium nitrate mixture[1] added, which throws down imidodiphosphoric, pyrophosphoric, and orthophosphoric acids, while diimidotriphosphoric acid remains wholly in solution. The liquid is removed as far as possible from the semigelatinous precipitate by suction and pressing out in the filter,[2] without washing. The filtrate is approximately neutralized with nitric acid and precipitated by silver nitrate, a considerable excess of which should be used, as penta-silver diimidotriphosphate is much less soluble in dilute silver nitrate than in water. The slightly washed silver salt still contains some imidodiphosphate, as the magnesium salt of this acid is not wholly insoluble. To remove this it is dissolved in the smallest possible volume and amount of ammonia and a little magnesium nitrate mixture added, which throws out the remaining imidodiphosphoric acid. The liquid is again filtered by suction, with but little washing, and the silver salt again precipitated by neutralizing with nitric acid, with addition of a little silver nitrate. The moist silver salt is treated with an excess of moderately strong solution of sodium chloride, acidified with acetic acid, the silver chloride filtered off with but little washing and an equal volume of alcohol added to the filtrate, which precipitates tri-sodium diimidotriphosphate. This is purified by dissolving in a little water and reprecipitating by alcohol.

The magnesium precipitate, containing imidodiphosphoric, orthophosphoric, and a little pyrophosphoric acids, is pressed out strongly under a screw press, pulverized, and dissolved in the least possible amount of dilute nitric acid.[3] Ammonia is added drop by drop till a slight permanent precipitate forms, and after filtering, silver nitrate added as long as the precipitate is white. Nearly all the orthophosphoric acid remains in solution, even after adding much silver nitrate; but, if too much be added, or if the amount of orthophosphoric acid be relatively great, the latter portions of the precipitate are yellow. Exact quantitative data can not be given, but in general it is necessary to use an amount of silver nitrate at least ten times the weight of the mixed magnesium salts. Silver pyrophosphate is partly precipitated toward the end, and partly

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[1] Made by dissolving 100 grams crystallized magnesium nitrate and 35 grams ammonium nitrate in water, adding enough ammonia to give a faint odor and diluting to 1 liter.

[2] Schleicher and Schüll's hardened filters, No. 575, have proved indispensable in this operation.

[3] This is best done by rubbing up with water in a glass mortar, adding the acid gradually.

remains in solution. To get rid of it entirely, as well as of traces of orthophosphoric acid and of a substance of relatively high percentage of nitrogen, the tri-silver imidodiphosphate must be dissolved in ammonia, reprecipitated as magnesium salt, pressed out, and reconverted into the silver salt in the same manner. The mother liquor of the second silver precipitation, if neutralized with ammonia, gives a mixture of silver imidodiphosphate and pyrophosphate. This, after conversion into the sodium salt by sodium chloride, addition of a little caustic soda, and precipitating by alcohol, gives a sirup which is converted by vigorous rubbing into a pasty mass. This, by repeated solution and reprecipitation by alcohol, gives the characteristic flat prisms of sodium pyrophosphate. After conversion into the silver salt this proved to be free from nitrogen and an analysis gave:

	Calculated for $Ag_4P_2O_7$.	Found.
Ag	71.27	70.23

Tedious as the above method is, many experiments have failed to lead to the discovery of a better one, and have convinced me that it can not be abbreviated in the least without injuriously affecting the quality of the products.

Diimidotriphosphoric Acid, $P_3N_2O_8H_7$.

This acid forms two series of salts in which 3 and 5 atoms of hydrogen are replaced. The alkali salts with 3 atoms of metal are of neutral; those with 5 atoms of alkaline reaction. It seems impossible to replace the 2 remaining atoms, as is pointed out under the silver salts.

Tri-sodium diimidotriphosphate, $P_3N_2O_8H_4Na_3$.—The preparation of this salt is described above. It is easily soluble in water, this solution leaving on evaporation a mass of indistinct prisms. Precipitated from its aqueous solution by alcohol, it usually forms granules without evidence of crystalline form; but when very slowly precipitated it may be obtained as flat, very obtusely pointed prisms or rhombic plates, visible only when magnified 400 diameters. It contains no crystal water. The substance dried at 100° gave:

	Calculated for $P_3N_2O_8H_4Na_3$.	Found.
P	28.89	28.73
N	8.72	8.77
Na	21.45	20.69

P : N : Na = 3 : 2.02 : 2.92.

A penta-sodium salt probably exists, being obtained by decomposing the penta-silver salt with sodium chloride. It has alkaline reaction *and is precipitated* by alcohol as an uncrystallizable sirup.

The tri-sodium salt is not precipitated even in strong solution by magnesium chloride or magnesia mixture unless the latter contains much ammonia; in this case the resulting precipitate is easily soluble in ammonium salts, and hence is probably merely magnesium hydroxide. Barium chloride precipitates from a not too dilute solution microscopic spherules, which dissolve readily in a cold, strong solution of sodium chloride. On boiling this solution a crystalline precipitate is at once formed, consisting of microscopic rhombohedra (?) resembling sodium barium trimetaphosphimate and probably a double salt.

Silver salts.—Two of these were obtained, one having the formula $P_3N_2O_8H_4Ag_3$, and the other $P_3O_2O_8H_2Ag_5$. The tendency to formation of the latter is so strong that a solution of the tertiary sodium salt gives, with silver nitrate, a white amorphous precipitate, which, however, is mixed with some crystals of the former.

Tri-silver diimidotriphosphate, $P_3N_2O_8H_4Ag_3$.—This salt is very characteristic. It can be obtained pure only by precipitating an acidified solution of the tertiary sodium salt by an excess of silver nitrate. To a solution of the sodium salt in 30 parts water, 1 to 2 molecular weights nitric acid are added, and then silver nitrate gradually; as soon as a milkiness, due to the formation of the penta-salt, is observed, more acid is added, and then more silver nitrate, acid being added as often as necessary; the crystallization soon starts, but several times the theoretical amount of nitrate is required, and under no circumstances is the precipitation complete. Generally spherules with many rhombic facets are obtained, but with slow crystallization (from more dilute solutions) the forms shown in figs. 5 and 6 result.

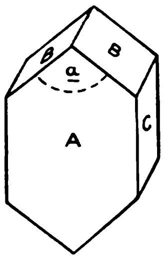


Fig. 5.

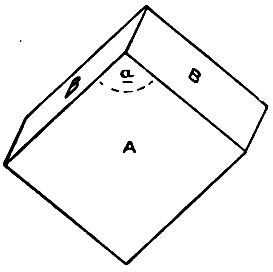


Fig. 6.

$A = \infty\ P\ \bar{\infty}$. $B = P\ \grave{\infty}$. $C = \infty\ P\ \grave{\infty}$.

The colorless crystals are monoclinic, and suggest those of tertiary silver trimetaphosphimate, but are shorter and thicker, and approach more nearly to the orthorhombic form. No other faces are ever seen. The angle *a* (between the edges), measured under the microscope, is very nearly 98°; the acute angle between the edges of B is, roughly speaking, 80°, so that when the form fig. 6 occurs, and this face is uppermost, it is apt to be mistaken under superficial observation for trimetaphosphimate (angle *a*, 78°).

The salt is practicably insoluble in water, easily in ammonia, and rather difficultly in dilute nitric acid. When pure it is not discolored by light or by caustic soda. It contains no crystal water. Analysis gave:

	Calculated for $P_3N_2O_8H_4Ag_3$.	Found.	
		1.	2.
P	16.14	16.39	16.29
N	4.87	4.76	....
Ag	56.10	55.94	56.36

1. P : N : Ag = 3 : 2.01 : 2.94. Direct from decomposed solution of trimetaphosphimic acid.
2. P : Ag = 3 : 2.99. From sodium salt.

Penta-silver diimidotriphosphate, $P_2N_2O_8H_2Ag_5$. — One molecular weight tertiary sodium salt is dissolved with addition of not less than 1½ nor more than 4 molecular weights ammonia, and added to an excess of a solution of silver nitrate; the pure white amorphous voluminous precipitate is washed, sucked out, and dried in vacuo. When fresh it is colorless, but on drying it assumes a yellowish tint, and after standing for some time it is partially converted into crystals, the nature of which was not determined. On boiling with water it also becomes yellowish, and in each case the change of color is accompanied by decomposition, as its ammoniacal solution is partially precipitated in amorphous form by magnesia mixture, an effect which is not observed in the perfectly fresh white salt. Warming with ammonium nitrate destroys the yellow color, which is consequently not due to silver phosphate. The fact that it remains white on boiling with ammonium nitrate serves to distinguish it from the trimetaphosphimates, the more basic silver salts of which, as pointed out, become orange-red under these conditions. The salt is very difficultly, yet perceptibly, soluble in water, and is reprecipitated by adding considerable silver nitrate; it is easily soluble in ammonia, and nitric acid converts it partly into the tertiary salt before dissolving it.

Dried at 100° it gave:

	Calculated for $P_3N_2O_8H_2A\;_5$.	Found.		
		1	2	3
P	11.77	12.05	11.96	11.75
N	3.55	3.66	3.65	....
Ag	68.23	68.96	68.92	69.24

1. P : N : Ag = 3 : 2.02 : 4.94.
2. P : N : Ag = 3 : 2.02 : 4.97.
3. *P : Ag* = 3 : 5.08.

Attempts to replace one or both of the remaining hydrogen atoms by silver proved unsuccessful. If the tertiary sodium salt be dissolved with 1-2 molecular weights caustic soda, or even with 5-6 molecular weights ammonia, and added to silver nitrate, the resulting precipitate is discolored by free silver oxide. On standing several days it becomes yellow, but its ammoniacal solution is now precipitated by magnesia mixture, indicating decomposition. The magnesia precipitate gave a silver salt resembling tertiary imidodiphosphate, but the exact nature of the decomposition was not investigated.

IMIDODIPHOSPHORIC ACID, $P_2NO_6H_5$.

This is probably the substance described by Gladstone under the name pyrophosphamic acid. It is moderately stable in cold, not too acid, solution, and hence occurs in large amount among the decomposition products of trimetaphosphimic acid.

Tri-sodium imidodiphosphate, obtained by decomposing the tertiary silver salt by sodium chloride, has alkaline reaction. Its solution, as well as that of the tetra sodium salt, is precipitated by alcohol as a sirup which can not be made to crystallize, and the aqueous solution of which dries to a transparent gummy mass. It is more soluble in dilute alcohol than sodium pyrophosphate.

The magnesium salt above described is amorphous, voluminous, and nearly, but not quite, insoluble in water, and somewhat more soluble in solutions of ammonium salts.

Tri-silver imidodiphosphate, $P_2NO_6H_2Ag_3$.—This is obtained as an amorphous, white precipitate, when the free acid, or a solution of a tertiary salt is precipitated by silver nitrate. Thus formed, it tends to collect in small lumps, a property which distinguishes it from any of the other silver salts referred to in this paper. When precipitated by acid from its ammoniacal solution it forms a powder that settles slowly. When slowly separating, or when precipitated from hot solutions, it forms semicrystalline granules, often united to crusts or dendritic forms. When formed in a moderately acid solution it usually shows a slight deficiency of silver (analyses 1-2), probably due to a trace of a more acid salt; but such a salt can not be obtained in pure form. Pure tertiary salt can be obtained by decomposing the crude salt with somewhat less than the required amount of sodium chloride, and reprecipitating. It is insoluble in water and is not affected by light.

Dried at 100° it gave:

	Calculated for $P_2NO_6H_2Ag_3$.	Found.				
		1.	2.	3.	4.	5.
P....	12.47	13.19	12.75	12.34	12.60	12.19
N....	2.82	3.13	3.14	2.86	2.96	2.92
Ag...	65.03	63.70	63.87	65.21	65.06	66.46

1. P : N : Ag = 2 : 1.05 : 2.78.
2. P : N : Ag = 2 : 1.09 : 2.78.
3. P : N : Ag = 2 : 1.02 : 3.04.
4. P : N : Ag = 2 : 1.04 : 2.97.
5. P : N : Ag = 2 : 1.06 : 3.14.

Tetra-silver imidodiphosphate, $P_2NO_6HAg_4$.—This salt exists in a white and in a yellow form. The former is obtained by precipitating a solution of silver oxide in ammonium nitrate by the sodium salt. It forms a voluminous, flocculent precipitate, which remains white only in presence of its mother liquor; on washing out it undergoes partial transformation into the yellow form, the same change occurring temporarily on boiling under the mother liquor. It shows a slight deficiency of silver (analysis 4).

The yellow form is obtained as an amorphous, flocculent precipitate by adding an ammoniacal solution of an imidodiphosphate to an excess of silver nitrate (analyses 1–2), or as an imperfectly crystalline powder, by evaporating such an ammoniacal solution, containing an excess of silver, over sulphuric acid (analysis 3). From this it appears that the remaining hydrogen atom is not replaceable by metal. The difference between the white and yellow forms is perhaps due to tautomerism.

Dried at 100°, it gave:

	Calculated for $P_2NO_6HAg_4$.	Found.			
		1.	2.	3.	4.
P................	10.27	10.17	10.07	....	10.80
N................	2.32	2.28	2.45	....	....
Ag................	71.39	72.19	72.35	71.01	69.72

1. P : N : Ag = 2 : 0.99 : 4.01.
2. P : N : Ag = 2 : 1.07 : 4.13.
3. P : Ag = 2 : 3.71.

Imidodiphosphoric acid is easily distinguished from diimidotriphosphoric acid by the insolubility of its magnesium salt, by the peculiar granular or lumpy appearance of its tertiary silver salt, by its sirupy tertiary sodium salt, and by its ammoniacal solution giving a yellow salt with silver nitrate, while the silver salt of the latter, found under the same conditions, is either white, or, when too much ammonia has been used, discolored by silver oxide.

Ferric imidodiphosphate.—No analysis of this was made. It is thrown down on boiling an acidified solution with a ferric salt as a white, amorphous precipitate, difficultly soluble in acids and easily soluble in ammonia.

Cupric imidodiphosphates.—Several of these appear to exist. The amorphous, light-blue precipitate formed by cupric sulphate in a solution of the sodium salt redissolves in an excess of the latter, is again reprecipitated by an excess of cupric salt, but under no circumstances completely. It dissolves in caustic potash to a violet solution. The soluble sodium double salt is partially precipitated on heating its aqueous solution, the precipitate redissolving on cooling. The precipitate with excess of cupric sulphate dissolves readily in cold acetic or sulphurous acid, and is temporarily reprecipitated on heating the solution, unless too dilute and too strongly acid, in which case some pyrophosphate crystallizes out on long heating. The same temporary precipitation occurs in a less degree on heating its solution in very dilute nitric acid.

The property of being precipitated from an acid solution on boiling is one which cupric imidodiphosphate shares with the pyrophosphate, and the same is observed with the magnesium salts, but with the difference that the pyrophosphates do not redissolve on cooling, while the imidodiphosphates redissolve either at once or in a short time. It is not possible to effect a complete separation of the two acids in this way, however, for if pyrophosphoric acid be present, more or less imidodiphosphate remains in the permanent precipitate, apparently because of the formation of complex salts containing both acids. The only method for separating the two acids when mixed in approximately equal proportions is to convert them into the sodium salts, and to precipitate repeatedly by alcohol, finally recrystallizing the pyrophosphate from water.

Decomposition of imidodiphosphoric acid.—When a soluble imidodiphosphate is boiled with acetic acid, it is converted for the most part into orthophosphoric acid, and to a much less extent into pyrophosphoric acid. The signficance of this fact is pointed out in the introduction to section 2 of this paper. A solution of the sodium salt (which analysis has proved to be free from pyrophosphate) in 30–50 parts water is weakly acidified with acetic acid, boiled seven to eight minutes, and cooled. If this solution be made alkaline with caustic soda, and alcohol added, an abundant crystallization of tertiary sodium phosphate is formed, which may be recognized by its crystalline form and by the usual reactions. In this the microscope shows a few crystals of sodium pyrophosphate. The latter acid may be isolated by making use of the fact that a solution of freshly precipitated magnesium pyrophosphate in excess of cold acetic acid is quantitatively precipitated on boiling, in a permanently insoluble form, while magnesium orthophosphate remains dissolved. The above weak acetic solution is mixed with magnesium acetate in excess, the precipitate dissolved by adding about one-fifth volume of strong acetic acid, and boiled a few minutes. The precipitated granular magnesium pyrophosphate is dissolved in nitric acid, in the manner described for the separation of the decomposition products of trimetaphosphimic acid, converted into silver salt and then into sodium salt. This, after several precipitations by alcohol, is recrystallized from water. A careful determination of the yield of pyrophosphoric acid in two experiments gave 13.5 and 16 per cent of the theoretical. For analysis the sodium salt was converted into silver pyrophosphate, which gave:

	Calculated for $Ag_4P_2O_7$.	Found.
P	10.24	10.35
Ag	71.27	70.74

DECOMPOSITION OF SODIUM TRIMETAPHOSPHIMATE BY ACETIC ACID.

As before pointed out, this salt is not decomposed by acetic acid in the cold, or on short heating. If, however, its solution is heated for two or three hours with 30 per cent acetic acid and magnesium acetate, under the conditions mentioned under the magnesium salt, a granular precipitate is obtained, consisting of a mixture or double salt of magnesium pyrophosphate and imidodiphosphate, which does not perceptibly redissolve on cooling, while the liquid contains much orthophosphoric acid. The sodium pyrophosphate, separated from this by the above method, showed the characteristic form. For analysis it was converted into the silver salt, and gave:

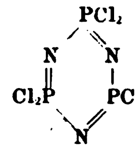
	Calculated for $Ag_4P_2O_7$.	Found.
P	10.24	10.43
Ag	71.27	70.33

3. ON TETRAMETAPHOSPHIMIC ACID.

Trimetaphosphimic acid and its decomposition products have been described in the preceding pages. Some account will now be given of the next higher member of the series, *tetrametaphosphimic acid*, $P_4N_4O_8H_8$, which results from the decomposition by water of tetraphosphonitrilic chloride, $P_4N_4Cl_8$. The molecular weight of the chloride having been established with certainty, that of the acid follows directly. Although the free acid crystallizes with 2 molecules of water, the silver salts and the acid potassium and ammonium salts are anhydrous and conform to the above formula.

Notwithstanding the proximity of these two acids in the series, and the general similarity of the chloronitrides from which they are derived, they differ exceedingly, trimetaphosphimic acid being extremely soluble, uncrystallizable, undergoing rapid spontaneous decomposition, and yielding but two series of salts; while tetrametaphosphimic acid is very difficultly soluble, highly crystalline, permanent when dry, offers marked resistance to the action of acids, and forms three series of salts, $P_4N_4O_8H_6M'_2$, $P_4N_4O_8H_4M'_4$, and $P_4N_4O_8M'_8$. Those metals which form insoluble salts are precipitated from solutions of their chlorides or nitrates even by the free acid, but a very slight excess of either being required to make the precipitation complete. As is the case with trimetaphosphimic acid, the 8-atom silver salt exists in a white and a yellow modification, the former, however, being very unstable; these may be regarded as corresponding to the tautomeric forms $(PN(OH)_2)_4$ and $(PO.NH.OH)_4$. Under the action of stronger acids it is ultimately converted into orthophosphoric acid and ammonia, but its great stability, and the instability of the intermediate products, have rendered the isolation of the latter impossible.

Experimental data for a discussion of the constitution of the acid are therefore almost wholly wanting. Presumably the phosphorus atoms in the nucleus P_4N_4 are united by nitrogen atoms, but whether they constitute a ring of 8 atoms can not be decided definitely in the absence of intermediate decomposition products. It is quite likely that the reason of the greater stability of the acid may be found in steric considerations, and in this connection it is interesting to observe that while $P_4N_4O_8H_8$ is much more stable than $P_3N_3O_6H_6$, the reverse is true of the chloronitrides, for while $P_4N_4Cl_8$ also resists the action of boiling water and can be distilled with steam, it is perceptibly easier to saponify than $P_3N_3Cl_6$. If we assume the formulas



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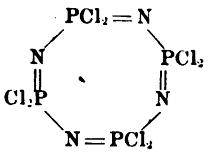
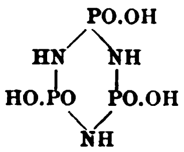


for the chloronitrides, and



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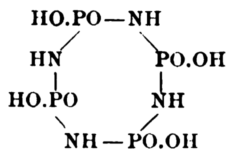

for the acids, it is obvious that the nitrile configuration is more stable in a ring of 6 than in one of 8 atoms, while for the group $-NH-PO(OH)-NH-$ the reverse is true.

EXPERIMENTAL PART.

Preparation of tetrametaphosphimic acid.—Tetraphosphonitrilic chloride can be saponified by alcoholic alkalies, but the yield of tetrametaphosphimic acid is poor, owing to the formation of ethers, which, however, can be decomposed by prolonged treatment. Satisfactory results are obtained by using an ethereal solution, which is agitated, in the manner described under trimetaphosphimic acid, with either water, ammonia, or a solution of ammonium acetate.

Decomposition by water.—As tetrametaphosphimic acid is not perceptibly attacked by cold hydrochloric acid, water may be used when it is desired to obtain the free acid directly. One part $P_4N_4Cl_8$ is dissolved in 15 volumes alcohol-free ether and gently agitated with 5 volumes water. Within half an hour needles of the free acid begin to separate from the aqueous portion, and after many hours the latter has become converted into a thick pasty mass of needles suspended in dilute hydrochloric acid. Chlorhydrines are formed as intermediate products, and these remain dissolved in the ether. It is not necessary to continue the agitation until they are completely decomposed; as soon as a few drops of the ether leave a residue wholly soluble in water, the ether is decanted and the aqueous portion filtered, the crystals being washed with 10 per cent hydrochloric acid or alcohol. The ethereal portion, containing the chlorhydrines, is evaporated cautiously. The chlorhydrines which remain as an oil from which crystals separate after complete removal of the ether, are dissolved in a little cold water and warmed, with addition of dilute hydrochloric acid, in which tetrametaphosphimic acid is much less soluble than in pure water. The separation of the acid is nearly complete after a few minutes. This portion is better crystallized than that obtained directly, but is otherwise the same. The acid may be recrystallized from hot water, but this is quite unnecessary. Yield, about theoretical.

Decomposition by ammonia.—The ethereal solution of the chloronitride is shaken for a short time with aqueous ammonia. This does not give chloramide as is the case with $P_3N_3Cl_6$, but produces at once neutral ammonium tetrametaphosphimate, $P_4N_4O_8H_4(NH_4)_4+4H_2O$, which is precipitated by adding alcohol and washed with dilute alcohol. The decomposition is complete in a few minutes.

Decomposition by ammonium acetate.—One part chloronitride, dissolved in 15 volumes ether, is agitated with a solution of 4 parts ammonium acetate in 8 parts water. After several hours crystals begin to separate. The final product is a mixture of acid ammonium salt with some neutral salt and some free acid, and is nearly insoluble in the strong salt solution. It is washed with alcohol, dissolved in dilute ammonia, and reprecipitated by alcohol. Yield, theoretical. Ammonium acetate is to be preferred to sodium acetate, as the sodium salt does not precipitate well with alcohol.

Chlorhydrines.—None of these were isolated. The oil left on distilling off the ether solidifies to plates as soon as the ether is completely removed. The crystalline substance is much more soluble in ether than the chloronitride, even momentary exposure to ether-vapor causing it to liquefy. It dissolves in cold water to a clear solution, from which, in a few minutes, or sooner on warming, tetrametaphosphimic acid is deposited. On one occasion the flask containing the chlorhydrines was placed in hot water and a current of dry air passed through. Some hydrochloric acid was given off, and on treatment with water incomplete solution occurred, a portion being converted into a sandy powder, which, under the microscope, was seen to consist of short, spindle-shaped crystals. This acid was insoluble in boiling water, and warm ammonia converted it without dissolving into an acicular ammonium salt, difficultly soluble in water and insoluble in an excess of ammonia; nitric acid dissolved this salt, which was precipitated by ammonia in a bulky amorphous form like precipitated alumina, which quickly changed to needles. This ammonium salt was very slowly attacked by hot concentrated sulphuric acid, and contained 27.96 per cent phosphorus and 13.28 per cent nitrogen (P : N=4 : 4.2). Lack of material prevented further study of this finely crystallized acid, of the nature of which I can form no conjecture.

Tetrametaphosphimic acid, $P_4N_4O_8H_8+2H_2O$.—The free acid may be prepared by the first method above described. It is not readily obtained pure by decomposing most of its soluble salts, as even in the presence of a large excess of acid more or less acid salt is deposited. Thus on dissolving neutral ammonium salt and adding a large excess of hot 5 per cent nitric acid, nearly pure acid salt was obtained. It may also be prepared by boiling the silver salt with much water, containing about the requisite amount of hydrochloric acid for its decomposition, and precipitating by further addition of the same acid to the filtrate.

The analytical methods are the same as those employed for trimetaphosphimates, but much longer heating with strong sulphuric acid is necessary because of its greater stability.

Analyses of four air-dried preparations gave:

	Calculated for $P_4N_4O_8H_8+2H_2O$.	Found.			
		1.	2.	3.	4.
P	35.23	35.01	35.27	35.38	35.20
N	15.94	15.93	....	15.99	15.92
H	3.41	....	....	3.55	3.59

1. P : N=4 : 4.02.
3. P : N : H=4 : 4.06 : 12.43. From chlorhydrine.
4. P : N : H=4 : 4 : 12.64. First method, from aqueous portion.

The crystal water is not given off in vacuo over sulphuric acid. At 100° it loses weight rapidly, then slowly, but the total loss never reaches the theoretical, a portion of the water being taken up in producing intramolecular changes.

Loss calculated for $2H_2O$	10.22
(1) Loss after twenty-four hours (weight constant)	9.37
(2) Loss after seventy-eight hours (weight constant)	8.91

If rapidly heated to 130–140° the loss is still less, and is soon replaced by a gain; after thirty hours at this temperature a net increase of 11.15 per cent, corresponding to somewhat more than 2 molecules H_2O, was observed, which must have come from the atmosphere. The product consisted of unchanged acid with ammonium phosphate and apparently pyrophosphate.

Tetrametaphosphimic acid forms colorless needles, either single or in radiating groups, and visible without a lens; they appear to consist of flat rectangularly terminated prisms. One hundred parts water at 20° dissolve 0.64 part crystallized acid; in boiling water it is somewhat more soluble, but is insoluble in alcohol. From its saturated aqueous solution it is partially precipitated by adding one of the stronger acids, and more rapidly if heated; 100 parts by weight of 10 per cent nitric acid at 20° dissolve only 0.26 part of the crystallized acid, but on decomposing its salts in the cold by an excess of acid it frequently dissolves completely and separates out later. Its saturated aqueous solution does not coagulate albumen. Boiling alkaline solutions cause no evolution of ammonia. Its stability toward acids is illustrated by the following: 0.1 gram, dissolved in 200 cubic centimeters water with 8 cubic centimeters strong nitric and some hydrochloric acid, was evaporated to dryness on the water bath, whereby a large part was recovered unchanged; ten minutes' heating would have sufficed for the total decomposition of the same quantity of trimetaphosphimic acid. Nitrous acid has no perceptible action.

Di-potassium tetrametaphosphimate, $P_4N_4O_8H_6K_2$.—The free acid dissolves easily in cold dilute caustic potash; on strongly acidifying with acetic acid the solution remains clear, but on warming the above salt is deposited as a heavy, sandy powder, consisting of microscopic thick rectangular (quadratic?) prisms with basal planes. It is very difficultly soluble even in boiling water.

The air-dried substance lost nothing at 100° and gave:

	Calculated for $P_4N_4O_8H_6K_2$.	Found.
P	31.61	31.26
K	19.93	20.05

P : K = 4 : 2.03.

The tetra-potassium salt formed large, flat, obliquely terminated plates, very soluble, and was not isolated.

Tetra-sodium tetrametaphosphimate, $P_4N_4O_8H_4Na_4 + 2\frac{1}{2}(?)\ H_2O$.—The acid is suspended in a little water and an excess of dilute caustic soda added, whereby complete solution occurs. The separation of the neutral salt soon begins in the form of obliquely terminated flat prisms, sometimes single, sometimes in twins or quadruplets; the filtrate deposits more on heating, but in imperfect forms, broader at one end than at the other. Sometimes nothing separates from the alkaline solution until it is heated. On the contrary, strong caustic soda converts the solid acid in the salt without dissolving it. The salt is rather difficultly soluble in cold, quite easily in hot, water, but much less soluble in the presence of an excess of alkali, and the latter throws it down from its saturated aqueous solution. Sodium carbonate gives the same salt.

The substance, pressed out without washing and dried in vacuo, lost nothing at 100° and gave:

	Calculated for $P_4N_4O_8H_4Na_4 + 2\frac{1}{2}H_2O$.	Found.	
		1	2
P	27.62	27.61	27.71
Na	20.50	21.23	20.80

1. P:Na = 4:4.14.
2. P:Na = 4:4.05.

Alcohol precipitates this salt in a slimy form, which filters with difficulty.

A solution of the tetra-sodium salt, strongly acidified with acetic acid, gave a deposit of granules, probably the acid salt. A salt with more than 4 atoms of sodium[1] was not observed.

Tetra-ammonium tetrametaphosphimate, $P_4N_4O_8H_4(NH_4)_4+4H_2O$.—Strong ammonia converts tetrametaphosphimic acid into this salt without dissolving it; from its solution in weaker ammonia it is precipitated by alcohol. It usually forms well-developed, flat, monoclinic prisms with pinakoid and basal planes, the base being occasionally replaced by a set of many small planes. It is easily soluble in water, but difficultly in strong ammonia. Its solution undergoes partial decomposition into acid salt on evaporating. It loses nothing in vacuo, and analysis gave:

	Calculated for $P_4N_4O_8(NH_4)_4 +4H_4O$.	Found.		
		1	2	3
P	27.19	27.12	....	27.25
N	24.61	24.74	....	24.66
H	6.15	....	5.94	....

1. P:N = 4:8.12.
3. P:N = 4:8.

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[1] Compare the behavior of trimetaphosphimic acid toward excess of alkali.

Di-ammonium tetrametaphosphimate, $P_4N_4O_8H_6(NH_4)_2$.—This salt forms whenever a solution of the neutral salt is strongly acidified, and was at first mistaken for the free acid, which it somewhat resembles. It forms 4- and 6-sided prisms with base (tetragonal?), closely resembling the acid potassium salt, and, like this, is very difficultly soluble even in boiling water. It separates on heating a solution of the neutral salt with acetic acid in excess (analyses 1 and 2), or with a stronger acid, in which case it may be slightly contaminated with free acid. The preparation under analysis 3 was crystallized from a large excess of hot 5 per cent nitric acid. It contains no crystal water. Analysis gave:

	Calculated for $P_4N_4O_8H_6(NH_4)_2$.	Found.		
		1.	2.	3.
P	35.42	34.41	35.10	35.20
N	24.04	24.32	24.33	23.17

1. P:N=4:6.26.
2. P:N=4:6.15.
3. P:N=4:5.82.

Barium tetrametaphosphimate, $P_4N_4O_8H_4Ba_2 + 2H_2O$.—A solution of the di- or tetra-ammonium salt in 500 parts cold or, better, boiling water, is precipitated by an excess of barium chloride. The salt forms a voluminous precipitate consisting of microscopic needles, branched or forked, insoluble in water, and undecomposed by acetic acid. These have approximately the composition of neutral salt, with a slight deficiency of barium.

The air-dried salt lost nothing at 100° and gave:

	Calculated for $P_4N_4O_8H_4Ba_2 + 2H_2O$.	Found.	
		1.	2.
P	20.28	20.17	20.18
Ba	44.83	42.91	42.39

1. P:Ba=4:1.93. From acid ammonium salt.
2. P:Ba=4:1.90. From neutral ammonium salt.

Basic barium salts of indefinite properties seem to exist, but no indication of an acid salt could be obtained.

No satisfactory results were obtained with *magnesium* salts, a large variety of crystalline and amorphous precipitates being obtained under different conditions.

Manganese salts give with free tetrametaphosphimic acid a flocculent precipitate of neutral manganese tetrametaphosphimate; on adding a mineral acid this is decomposed, according to the proportion of the latter, into acid salt or free acid, or a mixture of both. The acid salt forms handsome pinkish rectangular plates, often superposed at various angles, and is one of the most characteristic salts obtained.

Ferric chloride gives no precipitate with a cold dilute solution of the neutral ammonium salt; on warming a white amorphous precipitate forms, which is soluble only on warming with much hydrochloric acid, from which solution, on cooling, the free acid separates.

Tetra-silver tetrametaphosphimate, $P_4N_4O_8H_4Ag_4$.—If to a cold solution of tetrametaphosphimic acid silver nitrate be added the resulting precipitate is white, curdy, and, under the microscope, granular or amorphous; formed in the presence of some alcohol it is even flocculent. These amorphous precipitates, after drying, slowly change to needles, and this occurs at once if they be boiled under water. The salt is obtained at once in crystalline form if a slight excess of silver nitrate be added to a hot solution of tetrametaphosphimic acid in 200–300 parts water. It requires but a slight excess of silver nitrate to bring about complete precipitation, the liberated nitric acid exercising a scarcely perceptible solvent action. Neutral ammonium salt may be used, but the addition of a little nitric acid is essential, otherwise the product is yellowish from contamination with the 8-atom silver salt.

When precipitated hot the salt sometimes consists of thick needles with tufts or brushes at each end, sometimes of long pointed plates, more rarely of rhombic plates, and in no case are they well formed or very characteristic. An acid salt could not be obtained, but the neutral salt always shows a slight deficiency of silver.

The air-dried substance lost nothing at 100° and gave:

	Calculated for $P_4N_4O_8H_4Ag_4$.	Found.					
		1.	2.	3.	4.	5.	6.
P	16.68	16.78	17.04	17.04	16.68	16.84	16.74
N	7.55	....	....	....	....	....	7.62
Ag ...	58.04	....	57.06	56.13	57.09	57.09	57.40

2. P : Ag = 4 : 3.85.
3. P : Ag = 4 : 3.79.
4. P : Ag = 4 : 3.94.
5. P : Ag = 4 : 3.90.
6. P : N : Ag = 4 : 4.02 : 3.95.

Octa-silver tetrametaphosphimate, $P_4N_4O_8Ag_8$.—If an ammoniacal solution of a tetrametaphosphimate be added to an excess of silver nitrate, a yellowish flocculent precipitate forms, which is insoluble in ammonium nitrate and which does not change on boiling under its mother-liquor or under pure water. On drying at 100° it became grayish olive colored, apparently because of the separation of some silver oxide. It gave the figures under 1, 2, and 3.

If a solution of a neutral tetrametaphosphimate be added to ammoniacal silver nitrate containing the least possible excess of ammonia, a nearly white flocculent precipitate forms in small amount, which is soluble in ammonium nitrate solution on gently warming; from this solution an orange-yellow semicrystalline body is thrown out on boiling for a moment. The latter is obtained in greater abundance by boiling the original filtrate from the silver-nitrate precipitate. It seems to be merely the crystalline modification of the above amorphous yellow salt. It gave the figures under analysis 4. The nearly white modification is obtained in greater amount by using a solution of silver oxide in ammonium nitrate solution. It shows a considerable deficiency of silver ($P : Ag = 4 : 6.7$) and seems to be less stable than the corresponding white hexa-silver trimetaphosphimate, as it can not be obtained entirely free from the yellow modification. The yellow form also shows a slight deficiency of silver, and unlike the trimetaphosphimate, it can not be converted into a red form.

The yellow salts, dried at 100°, gave:

	Calculated for $P_4N_4O_8Ag_8$.	Found.			
		1.	2.	3.	4.
P	10.59	10.47	10.88	10.80	10.89
Ag	73.69	71.86	71.60	71.96	72.21

1. $P : Ag = 4 : 7.90$.
2. $P : Ag = 4 : 7.57$. } Amorphous.
3. $P : Ag = 4 : 7.66$.
4. $P : Ag = 4 : 7.63$. Semicrystalline.

4. THE HIGHER CHLORONITRIDES.

In the first section of this paper I have shown that in addition to the phosphonitrilic chloride,[1] $P_3N_3Cl_6$, discovered by Liebig, there exists another, $P_4N_4Cl_8$, of similar properties, which is formed at the same time, but in smaller quantity. The opinion was expressed that these bodies belong to a series of polymers, $(PNCl_2)_n$, the existence of other members of which was indicated by the formation, in small amount, of a liquid of the same empirical composition. The yield of this secondary product, only 2 per cent of the theoretical or 1 per cent of the pentachloride used, was too small to allow of its preparation in quanti-

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[1] I propose in future to use the term phosphorus chloronitride to denote any body composed of phosphorus, nitrogen, and chlorine, the name phosphonitrilic chloride being reserved for chloronitrides belonging to the series $(PNCl_2)_n$.

ties large enough to admit of the isolation of its supposed constituents, but a fractional distillation of the few grams at my disposal showed that it contained crystalline substances of higher boiling points than those of the two bodies thus far known.

The method of preparation then employed consisted in distilling phosphorus pentachloride with a large excess of ammonium chloride in a retort, at atmospheric pressure; it offered but little prospect of obtaining the higher members. The total yield of phosphonitrilic chloride was but 15 per cent of the theoretical, most of the pentachloride being converted into "phospham" by the excess of ammonium chloride, while only those members could be obtained which distill unchanged at atmospheric pressure. Decreasing the amount of ammonium chloride resulted only in a loss of pentachloride by volatilization, without increasing the yield of the bodies sought after.

The following method has been found to give entirely satisfactory results; several new bodies have been obtained, and the simpler phosphonitrilic chlorides, at least, are now easily accessible substances. If equal molecular weights of phosphorus pentachloride and ammonium chloride be heated in a sealed tube, there results a mixture of chloronitrides, which is partly crystalline and soluble in gasoline, but for the greater part liquid and insoluble in this solvent, and of a high degree of complexity. This may be distilled almost without residue, the distillate being a crystalline mass, impregnated with an oil, and composed almost wholly of a mixture of members of the series $(PNCl_2)_n$ in nearly theoretical amount, containing about 50 per cent $P_3N_3Cl_6$, and 25 per cent $P_4N_4Cl_8$, the remainder consisting of the higher homologues. From this distillate the new bodies, with one exception, have been isolated.

The series, as at present known, consists of the following:

	Melting point. (Corrected.)	Boiling point. (Corrected.)	
		13 mm.	760 mm.
	Degrees.	*Degrees.*	*Degrees.*
Triphosphonitrilic chloride, $(PNCl_2)_3$.	114	127	*a* 256.5
Tetraphosphonitrilic chloride, $(PNCl_2)_4$.	123.5	188	*b* 328.5
Pentaphosphonitrilic chloride, $(PNCl_2)_5$.	40.5–41	223–224.3	Polymerizes
Hexaphosphonitrilic chloride, $(PNCl_2)_6$.	91	261–263	Polymerizes
Heptaphosphonitrilic chloride, $(PNCl_2)_7$.	Below —18	289–294	Polymerizes
Polyphosphonitrilic chloride, $(PNCl_2)_x$.	Below red heat.	Depolymerizes on distillation.	

a 183.8° at 100 mm. *b* 242° at 100 mm.

There were obtained, further, a liquid residue of the same empirical composition, of a mean molecular weight corresponding nearly to

$(PNCl_2)_{11}$, and a small amount of a chloronitride, $P_6N_7Cl_9$, not belonging to the above series. The absence of the lower members, $PNCl_2$ and $(PNCl_2)_2$, is remarkable, and theoretically significant. Indications of a trace of a substance more volatile than the compound $(PNCl_2)_3$ and of similar but stronger odor, were observed, but there is no evidence that it consists of one of the missing bodies.

One of the most remarkable properties of the phosphonitrilic chlorides is that each member of the series is converted by heat into the rubber-like polyphosphonitrilic chloride, a body, or mixture of bodies, of very high molecular weight, which is highly elastic and insoluble in all neutral solvents, but which swells enormously in benzene, and which, on distilling at a higher temperature, breaks down into a mixture of all the lower members mentioned above, which can then be separated by appropriate means. In this way it is possible to convert any phosphonitrilic chloride quantitatively into any other by heat and distillation alone. In preparing any desired member, therefore, we are not limited to the quantity obtained from the first reaction product, but may work the residues over and over again until completely converted into the body sought after. With the exception of a few cases, in which the number of members is limited, as the aldehydes and cyanic acids, this series is therefore unique; I know of no other series of inorganic compounds in which this is possible. Polymerization takes place slowly, but perceptibly, at 250°, and is almost instantaneous at 350°, while depolymerization begins at about 350°, and is rapid at a temperature close to incipient red heat. Triphosphonitrilic chloride, $P_3N_3Cl_6$, is the only member which can be distilled in considerable amount at atmospheric pressure without considerable polymerization, and even this polymerizes almost completely on long boiling; at 760 millimeters pressure the tetra-compound, $P_4N_4Cl_8$, boils at 328.5°, a temperature at which polymerization occurs quite rapidly, but this, as well as the penta compound, $P_5N_5Cl_{10}$, and the hexa-compound, $P_6N_6Cl_{12}$, can readily be distilled at 13 millimeters; the hepta-compound, $P_7N_7Cl_{14}$, suffers marked polymerization on distilling even at this pressure, and its isolation is therefore attended with much loss. Owing to the rapid change at higher temperatures, I have been unable to isolate any of the higher members, which remain as a considerable oily residuum, and there seems to be but little probability of this being effected by any known method, unless by distilling in a nearly absolute vacuum.

The greatest difficulty in the separation of the members is caused by polymerization. It requires but a small amount of polyphosphonitrilic chloride to cause the liquid to thicken or gelatinize, and therefore to be incapable of further distillation, and some of this body is always formed in the course of a prolonged fractioning of the higher members. It was found, however, that this polymer is much more easily attacked by water than the lower members; when signs of polymerization are observed, it is only necessary to interrupt the distillation, and heat the residue for some time with water, when the resulting oil is again in a condition to continue fractioning. The loss in this operation is small, but the tediousness of a fractional distillation is thereby extraordinarily increased.

It is noteworthy that no regular progression exists in the melting points of the phosphonitrilic chlorides, and the same is true of their solubility in the ordinary neutral solvents, but the solubility varies in the same sense as the fusibility. Of the members of known molecular weight, the second, tetraphosphonitrilic chloride, is the least soluble and has the highest melting point, while the corresponding tetrametaphosphimic acid is the least soluble and most stable of the derived acids. With respect to their stability toward water, the new members (polyphosphonitrilic chloride excepted) resemble those already described, being scarcely attacked by prolonged boiling. In ethereal solution, however, there is a perceptible decrease of stability toward water as we rise in the series, a fact already noted with regard to the first two members.

Notwithstanding the high molecular weight of the bodies isolated, no indication of isomers has been observed, although the fractioning was carried out very thoroughly up to 300° at 13 millimeters.

EXPERIMENTAL PART.

A mixture (which need not be very intimate) of 4 parts perfectly dry phosphorus pentachloride and 1 part ammonium chloride, as required by the equation

$$PCl_5 + NH_4Cl = PNCl_2 + 4HCl,$$

is introduced into an ordinary "bomb" tube, which has previously been drawn out to a neck. It is practicable to fill the tube entirely to the neck, so that the charge for a tube of ordinary dimensions is about 125 grams, yielding 50–55 grams of chloronitrides. After sealing, the length of the neck, exclusive of the rather long capillary, should be about 10 centimeters. As the mixture liberates 55 per cent hydrochloric acid, it is necessary to regulate the heating with great care and to open the tube repeatedly. The temperature of the furnace is allowed to rise to 150°, at which the reaction begins, when the gas is at once shut off, and the tube opened at about 100° (in the furnace!). This operation is repeated several times, the temperature being allowed to rise 1°–2° higher each time. When the evolution of hydrochloric acid has slackened and the contents of the tube are mainly liquid while hot, the temperature may be carried to 200° or higher, until little or no gas is given off. The operation requires care and judgment, but with careful working it is possible to avoid explosions, and to obtain with a four-tube furnace about 200 grams of mixed chloronitrides in sixteen hours.

The contents of the tube, after cooling, generally consists of a buttery mass or of a thick, yellow liquid filled with fine prisms and plates; if heated much above 200°, the liquid frequently separates into two layers. The crystals are soluble in gasoline, but the bulk of the product remains as an immiscible oil.

The neck of the tube is now bent down, the tube placed in an inclined combustion furnace, and by cautious heating, finally to incipient redness, the contents are distilled out. There remains in the tube a very voluminous, spongy, black residue of inconsiderable weight, due to unavoidable impurities and to the impossibility of causing complete reaction in the sense of the above equation. The distillate consists of a crystalline mass impregnated with a yellow oil, and contains about 95 per cent of the theoretical amount of phosphonitrilic chlorides, with some phosphorus pentachloride, the chloronitride $P_6N_7Cl_9$, and other substances of unknown nature. Before proceeding further, it is necessary to remove the pentachloride, and for this purpose the distillate is melted, poured into cold water, and the flask heated in the water-bath for about two hours, the liquids being mixed by blowing air through them. The chloronitrides are then allowed to clear under the hot water, and forced out by means of a wash-bottle arrangement; a separatory funnel can not be used, as the substance solidifies in the neck, and if allowed to solidify under the wash water it absorbs so much of this as to cause annoyance in the subsequent distillation. Special drying before distilling is unnecessary.

The product is then distilled up to 200° at 13–15 millimeters, using an Anschütz flask, as the distillate solidifies instantly on cooling. The residue, containing the members $P_5N_5Cl_{10}$ up, is set aside for later systematic fractional distillation.[1] The distillate, about 70 per cent, consists essentially of $P_3N_3Cl_6$ and $P_4N_4Cl_8$, which, if desired, may be easily separated by fractional distillation in vacuo, followed by crystallization from benzene. This is more convenient than the method of separating by steam. If it is desired to convert it into the higher members, it is placed in a combustion tube bent down at about 20 centimeters from the open end, and which it should not fill more than one-half after melting. This is laid in an inclined combustion furnace and heated to gentle boiling of the contents. It is well to heat the tube somewhat strongly at a short distance above the liquid, as superheating the vapor pro-

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[1] This residue contains the small amount of $P_6N_7Cl_9$ formed as a secondary product of the original reagents, and as this is apt to cause inconvenience at a later stage by accumulating with the $P_6N_6Cl_{12}$, it is perhaps well to remove as much as possible at this point. For this purpose the residue is allowed to stand for a day or two at the room temperature, and the crystals removed by sucking out under a good vacuum, best in a large Gooch crucible. The filtrate is cooled for a day or two in a refrigerator, and the new crop of crystals separated in the same way, the filtering flask being allowed to stand in the icebox. The oily filtrate is set aside, and the united crystalline products distilled up to 240° at 13 millimeters, whereby most of the $P_5N_5Cl_{10}$ passes over. The residue, consisting of $P_6N_6Cl_{12}$, the small amount of $P_6N_7Cl_9$, and the adhering oil, is allowed to crystallize in the refrigerator, and the viscous mass is extracted several times with small amounts of gasoline (boiling at 50°–80°). The residue is boiled with benzene, which extracts the $P_6N_7Cl_9$, which crystallizes on concentrating and cooling. The portion dissolved by the gasoline is worked up with the other residues.

This is the method actually employed, but I am not entirely convinced of its necessity, as it is not possible to remove all the $P_6N_7Cl_9$ in this way.

motes polymerization. The time required for polymerization varies greatly; pure triphosphonitrilic chloride may require two hours or more. With the above mixture the time is less, and is shorter the higher the boiling point; it is shortened by adding already gelatinized substance, which causes the liquid to thicken, and may then be but a few minutes; it is also shortened by heating under pressure. Sooner or later the liquid begins to thicken, and finally it is converted into a stiff, transparent mass, with little or no liquid, and generally discolored by traces of organic matter. The tube is then connected with a long-necked receiver, exhausted, and the depolymerization and distillation effected by heating, from the front backward, to incipient redness. This part of the operation proceeds rapidly, as it is only necessary to guard against frothing over, and to insure complete condensation, the latter being easily effected by having the limb of the tube at least 20 centimeters long. One hundred grams can be worked up at one time and the tube can be used repeatedly. The residue does not weigh more than a few milligrams. The distillation may also be made at atmospheric pressure, but the yield of higher products is thereby diminished. The distillate, which entirely resembles that first obtained, excepting in containing no phosphorus pentachloride and no $P_6N_7Cl_9$, is distilled as before, the washing being omitted. In this way the whole quantity of material can finally be converted into a mixture of members higher than $P_4N_4Cl_8$.

The united residues boiling above 200° are now submitted to systematic fractional distillation at 13–15 millimeters, using an Anschütz flask, provided with a "trap," to prevent flowing back. During the first distillation polymerization generally begins when the temperature of the bath has reached 270°, but with later distillations at a higher temperature, and the higher the purer the fractions are. When polymerization begins, which is indicated by frothing and thickening, the operation is interrupted and the residue heated in the flask with water in the water bath until it has completely liquefied, which is assisted by agitation, the oil separated,[1] and the distillation continued. It has not been found practicable to continue the distillation at a higher temperature than that obtained by heating the bath to 370°, for the liquid begins to polymerize in a few moments, and but an inconsiderable distillate can be obtained. Moreover, at this temperature the polymer shows signs of breaking down into simpler bodies, and the distillate does not consist only of high-boiling members. The total amount of final residue is not very great, and, as shown below, consists likewise of phosphonitrilic chlorides of still higher molecular weight. In later distillations from 200° upward, polymerization usually stops the process at 260°–270°, but after appropriate washing the residue may be

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[1] In this case a separatory funnel may be used, as the mixture of higher chloronitrides is liquid below 80°.

distilled to a much higher temperature. After eight to ten distillations three main fractions are obtained, which are then worked up separately. As $P_5N_5Cl_{10}$, though crystalline, is extremely soluble, it is necessary to carry out the distillations with the first main fraction until a practically sharp boiling point is obtained, in which connection it may be noted that at 17–20 millimeters a change of 1 millimeter pressure causes a change of about 1° in the boiling point, and at 13 millimeters a change of about 2°. $P_7N_7Cl_{14}$, being liquid, must also be isolated by distillation only, but at its boiling point polymerization is so rapid that great loss ensues during a series of distillations.

$P_6N_6Cl_{12}$ can not be separated by distillation from the $P_6N_7Cl_9$ which accompanies it in small amount, the latter having nearly the same boiling point, nor is repeated recrystallization effective. The separation is best effected by adding a crystal of pure $P_6N_6Cl_{12}$ to the supersaturated benzene solution, and filtering before the $P_6N_7Cl_9$ begins to deposit. The latter thus concentrated is recrystalized from benzene.

Owing to many modifications introduced in developing the above method, no accurate statement of the yield can be given; the final product was about 225 grams $P_5N_5Cl_{10}$, 110 grams $P_6N_6Cl_{12}$, 10 grams $P_7N_7Cl_{14}$, and 5 grams $P_6N_7Cl_9$.

Analytical methods.—With the exception of polyphosphonitrilic chloride, the chloronitrides were analyzed by decomposing in the following manner:

For phosphorus, by warming with alcohol and a little ammonia in a platinum crucible until completely dissolved, evaporating to dryness and heating to fuming for an hour with strong sulphuric acid, the crucible being kept covered.

For nitrogen, by treating as above, omitting the ammonia.

For chlorine, by heating with alcohol and ammonia. It is necessary to precipitate with silver nitrate in the presence of a large volume of 10 per cent nitric acid and to filter hot, in order to avoid the formation of silver metaphosphimates, which are difficultly soluble in dilute nitric acid.

In decomposing polyphosphonitrilic chloride, which is attacked by water alone, the alcohol was omitted. The method of Carius was used for determining chlorine, as it was found that otherwise compounds insoluble in dilute nitric acid were formed. For the other chloronitrides this method offers no advantage.

Molecular weight determinations were made by the boiling-point method with the apparatus of Hite,[1] using as solvent carefully purified and dried benzene.

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[1] Am. Chem. Jour., Vol. XVII, p. 512. The molecular weight of $P_3N_3Cl_6$ has been determined by the vapor-density method, Jour. Chem. Soc. London [2], Vol. II, p. 225. A series of determinations by the boiling-point method gave 346, 350, 353. Calculated 347.9.

Pentaphosphonitrilic chloride, $P_5N_5Cl_{10}$.—This body, carefully purified by fractional distillation, as described above, gave on analysis:

	Calculated for $P_5N_5Cl_{10}$.	Found.
P	26.75	26.87
N	12.11	12.05
Cl	61.14	61.42

P : N : Cl = 1 : 0.99 : 2.00.

Molecular weight. (*Solvent, benzene.*)

Grams solvent.	Grams substance.	Elevation (degrees).	Molecular weight found.	Percentage variation from theoretical.
46.49	1.4688	0.137	619	+6.2
46.49	2.9439	.287	589	+1.6
46.49	4.4337	.437	583	+ .5

Calculated for $P_5N_5Cl_{10}$, 579.8.

Pentaphosphonitrilic chloride fuses at 40.5°–41°, and boils at 223°–224.3° (corrected) at 13 millimeters. Its vapor is without the pronounced and characteristic aromatic odor possessed by that of triphosphonitrilic chloride. At its melting point it is miscible in all proportions with benzene, gasoline, ether, and carbon disulphide, and can not be recrystallized from any of these solvents; in fact, small fragments liquefy instantly in their concentrated vapors. Glacial acetic acid also dissolves it quite readily, and from this solution water throws it out as an oil, solidifying at once on touching. It shows a decided tendency to superfusion, especially when not absolutely pure; when left by evaporating its ether or benzene solution, it may remain liquid for days, but solidifies at once on touching with a glass rod, usually to a decidedly crystalline mass, at other times to a transparent glass. The pure substance, when fused, slowly solidifies, long, flat crystals shooting out through the liquid, which are limited only by the size of the vessel, crystals of 10 centimeters in length being readily obtained. It contracts greatly on solidifying. When pure the solidified mass is naturally dry, but the least contamination with other members of the series causes a portion to remain liquid, which is easily detected by crushing on a piece of filter paper; this is a very good test of its purity. This tendency to superfusion must be borne in mind in separating it by fractional distillation; a nearly pure sample will remain liquid much longer than the higher or lower fractions. In ether solution it is perceptibly more easily attacked by water than the preceding chloronitride, but hot water alone is almost without action.

Hexaphosphonitrilic chloride, $P_6N_6Cl_{12}$.—After repeated crystallization from benzene,[1] this gave:

	Calculated for $P_6N_6Cl_{12}$.	Found.
P	26.75	26.98
N	12.11	12.37
Cl	61.14	60.98

P : N : Cl = 1 : 1.01 : 1.98.

Molecular weight. (*Solvent, benzene.*)

Grams solvent.	Grams substances.	Elevation (degrees).	Molecular weight.	Percentage variation from theoretical.
47.12	1.8058	0.152	673	—3.2
47.12	3.6190	.293	700	+0.6
45.72	1.0101	.083	711	+2.1
45.72	4.4898	.365	718	+3.2
45.72	8.0070	.664	704	+1.2

Calculated for $P_6N_6Cl_{12}$, 695 8.

Hexaphosphonitrilic chloride fuses at 90° (corrected), and boils at 261°-263° (corrected) at 13 millimeters, and at 281°-282° (corrected) at 26 millimeters. It may be recrystallized from benzene, in which, however, it is more soluble than triphosphonitrilic chloride; ether, gasoline, and carbon disulphide also dissolve it readily; in alcohol it dissolves somewhat slowly, with decomposition. It shows no tendency to superfusion. It crystallizes well, in rather large crystals, which were examined by Mr. Wirt Tassin, to whom I am indebted for the following statement:

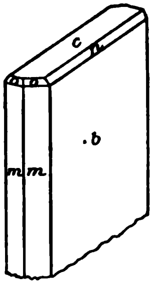

Fig. 7.

"$P_6N_6Cl_{12}$ crystallizes in the orthorhombic system in long, prismatic crystals, showing the following forms: *c* (001), *b* (010), *m* (110), *o* (111), *n* (011). Of these *c* is the dominant form; *b* large and well developed; *m* fair, though usually narrow, and *o* and *n* small and usually in similar development. *c*, *b*, *m*, *o* is the combination occurring most frequently; less often *c*, *b*, *m*, *n*, *o;* and rarely *c*, *b*, *m*. Angles *m*: *m* 57° 28′, *b*: *m* 61° 16′, *b*: *n* 40° 23′, *n*: *c* 49° 37′. Axial ratio *a* : *b* : *c* = 0.54824 : 1 : 1.17568. The crystals are optically positive. Plane of the optic axes (100);

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[1] A contamination with $P_6N_7Cl_9$ may be detected by treatment with gasoline, when the much smaller crystals of the latter are seen to dissolve much more slowly.

colorless to white; transparent, and have a perfect basal cleavage." (See fig. 7.)

It is scarcely attacked by boiling water, but if kept in moist air it very slowly evolves hydrochloric acid. Its ether solution, shaken with water, slowly gives a metaphosphimic acid; sirupy chlorhydrines are formed as intermediate products.

Heptaphosphonitrilic chloride, $P_7N_7Cl_{14}$.—After many distillations, this gave:

	Calculated for $P_7N_7Cl_{14}$.	Found.
P	26.75	26.57
N	12.11	12.12
Cl	61.14	61.28

P : N : Cl = 1 : 1.01 : 2.02.

Molecular weight. (*Solvent, benzene.*)

Grams solvent.	Grams substance.	Elevation (degrees).	Molecular weight.	Percentage variation from theoretical.
47.09	3.5621	0.250	808	—0.5
47.09	7.3979	.523	802	—1.2

Calculated for $P_7N_7Cl_{14}$, 811.7.

Heptaphosphonitrilic chloride is a nearly colorless, rather viscous liquid, which does not solidify at —18°, and which boils at 289°–294° (corrected) at 13 millimeters, undergoing some polymerization. It is readily miscible with benzene, gasoline, and ether, and toward water shows the stability manifested by the preceding chloronitrides.

Residual oily phosphonitrilic chlorides.[1]—The residue, which did not distill at 13 millimeters when the temperature of the bath was 370°, was boiled with water to remove the solid polyphosphonitrilic chloride, filtered, and carefully dried in vacuo over sulphuric acid. It is a thick liquid which gave on analysis:

	Calculated for $(PNCl_2)_x$.	Found.
P	26.75	26.79
N	12.11	12.39
Cl	61.14	62.00

P : N : Cl = 1 : 1.02 : 2.02.

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[1] It is unlikely that these consist entirely of the original depolymerization products; a portion is doubtless formed by polymerization during distillation.

Although the oil is doubtless a mixture, the above figures show that the constituents are members of the series $(PNCl_2)_n$. A determination of the mean molecular weight was made, with the following results:

Grams solvent.	Grams substance.	Elevation (degrees).	Molecular weight.
46.72	4.130	0.178	1,326
46.72	7.853	348	1,290

Mean 1,308. This does not lie far from that required by the formula $P_{11}N_{11}Cl_{22}$ (calculated, 1,276). This result is interesting in as far as it shows that a phosphonitrilic chloride of this molecular weight may exist; that it is stable and miscible with benzene, gasoline, and ether, and that the molecular weight of the solid polymer described below, which is insoluble, is probably very much higher. The oil has a reddish-brown color, due to dissolved impurities, which are destroyed by heating with strong nitric acid. It can not be distilled even at 13 millimeters, as it polymerizes almost instantly. In its behavior toward water it resembles the preceding members of the series.

Polyphosphonitrilic chloride $(PNCl_2)_x$.—This remarkable body, frequently alluded to above, is formed when any of the lower members are heated, slowly at 250°, and very rapidly at 350°. As the change is reversible, complete transformation can not be effected, but reaches perhaps 90 per cent, the remainder consisting not only of the original phosphonitrilic chloride, but of others. These can be extracted by anhydrous benzene. The sample, the analysis of which is given, was prepared by heating pure triphosphonitrilic chloride in a sealed tube at 350°–460°. The transparent elastic product was repeatedly extracted with benzene dried over sodium and the absorbed benzene removed in a vacuum with constant exhaustion over paraffin, and finally by heating in vacuo at 110°. Analysis gave:

	Calculated for $(PNCl_2)_x$	Found.
P	26.75	26.78
N	12.11	12.27
Cl	61.14	60.45

P:N:Cl = 1:1.01:1.98.

Polyphosphonitrilic chloride, when perfectly pure, is colorless and transparent, but is generally somewhat discolored by traces of organic matter. Its most striking property is its elasticity. It may be drawn out like rubber, and shows even a greater tendency to rebound from hard surfaces. It is readily cut with the shears. It is insoluble in all neutral solvents, but absorbs benzene, swelling to many times its original volume and forming a jelly of but little coherence; on evaporating the benzene it returns to its original condition. Ether is absorbed, but less readily, and other chloronitrides are taken up in a similar manner. Hot water slowly dissolves it with decomposition; in warm dilute ammonia it swells, gelatinizes, and finally dissolves; hot caustic soda does not dissolve it readily, apparently insoluble sodium salts being formed. It begins to depolymerize toward 350°, and this change is rapid just below red heat, and is accompanied by partial fusion, the products being, as described above, a mixture of lower phosphonitrilic chlorides. These transformations are not modified by heating in an atmosphere of hydrochloric acid. When perfectly pure, it leaves no residue whatever on distilling. No difference could be detected in the product formed from different phosphonitrilic chlorides.

Nitrilo-hexaphosphonitrilic chloride, $P_6N_7Cl_9$.—The separation of this chloronitride, which does not belong to the phosphonitrilic chloride series, is described above. After four crystallizations from benzene, it gave:

	Calculated for $P_6N_7Cl_9$.	Found.
P	30.84	30.74
N	16.29	16.29
Cl	52.87	53.01

A molecular weight determination, kindly made for me by Dr. H. C. Jones, of the Johns Hopkins University, with a limited quantity of material, in benzene solution, gave 667; calculated for $P_6N_7Cl_9$, 603.5. This, with the analysis, suffices to establish the above molecular formula.

Nitrilo-hexaphosphonitrilic chloride strikingly resembles the phosphonitrilic chlorides. It fuses at 237.5° (corrected) and boils at 251°–261° (corrected) at 13 millimeters without change. The boiling point coincides closely with that of hexaphosphonitrilic chloride (261°–263°, corrected at 13 millimeters), hence it is found associated with the latter. Heated in small quantities on foil, it volatilizes without residue, but at a higher temperature in a sealed tube it undergoes a change the exact nature of which has not been determined, but which involves the formation of a substance resembling polyphosphonitrilic chloride, which yields lower phosphonitrilic chlorides on distilling. It crystallizes in transparent prisms of not more than 1 millimeter in length, apparently rhombic, which are often united to acicular forms. When pulverized it becomes electrified. It dissolves in about 20 parts cold and 5 parts boiling benzene,[1] is more soluble in carbon disulphide, but less soluble

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[1] Approximate only.

in gasoline and in ether. Toward water it is nearly as stable as hexaphosphonitrilic chloride, but is slowly attacked when exposed to atmospheric moisture. Hot dilute ammonia dissolves it very slowly, but more rapidly when alcohol is added.

This body is obviously a secondary product of the reaction of phosphorus pentachloride and ammonium chloride, as it is never found when a pure phosphonitrilic chloride is polymerized and depolymerized. It is noteworthy that no indication of other bodies of a similar nature has been observed, although no reason appears why they should not be formed at the same time. Whether it is in reality hexaphosphonitrilic chloride in which 3 chlorine atoms are replaced by one of nitrogen or not can not be decided at present.

5. THE HIGHER METAPHOSPHIMIC ACIDS.

In the preceding sections on the metaphosphimic acids it was shown that the two lower phosphonitrilic chlorides, $P_3N_3Cl_6$ and $P_4N_4Cl_8$, give on saponification two well-defined acids, trimetaphosphimic acid, $P_3N_3O_6H_6$ and tetrametaphosphic acid, $P_4N_4O_8H_8$. In a later section the existence of the higher phosphonitrilic chlorides $P_5N_5Cl_{10}$, $P_6N_6Cl_{12}$, and $P_7N_7Cl_{14}$ was shown, and it was further demonstrated that the series does not end here, but is continued through a number of members, which are incapable of separation by existing methods, and terminates with a rubber-like polymer of high molecular weight.

The work outlined in the present section was begun with the expectation of finding that each of the new phosphonitrilic chlorides would give on saponification the corresponding metaphosphimic acid of the general formula $(PNO_2H_2)_n$. The result, however, has not justified this anticipation. It has been found that penta- and hexaphosphonitrilic chlorides give true penta- and hexametaphosphimic acids, $(PNO_2H_2)_5$ and $(PNO_2H_2)_6$, but that heptaphosphonitrilic chloride gives, not $(PNO_2H_2)_7$, but an acid $(PNO_2H_2)_7 + H_2O$. The metaphosphimic series, therefore, appears to be limited by the acid $(PNO_2H_2)_6$.

The metaphosphimic acids are the lactams of the imidophosphoric amides,[1] and it is therefore not surprising that there should be a certain similarity of behavior between these and certain organic oxy- and amido-acids. The γ and δ oxy- and amido-acids, while existing as salts in alkaline solution, pass more or less readily in the free state into the inner anhydrides, the lactones and lactams, a behavior which is not observed when the hydroxyl or amido-group is still further removed from the carboxyl. Joh. Wislicenus has shown[2] that the geometric configuration of the lactone-giving acids is such as to bring the reacting groups into

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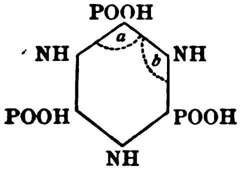
[1] The imidophosphoric acids consist of chains of alternate NH and PO groups, the first being imidodiphosphoric acid, $PO(OH)_2.NH.PO(OH)_2$. This and diimidotriphosphoric acid are described in the section on trimetaphosphimic acid, and triimidotetraphosphoric acid in the present section. The amides, of which the metaphosphimic acids are the lactams, may be regarded as imidophosphoric acids having one terminal hydroxyl replaced by an amido group.

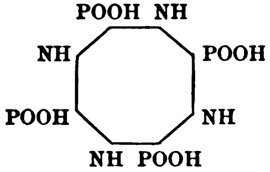
[2] Räumliche Anordnung der Atome, p. 67.

close proximity, thus admitting of inner anhydride formation, while in other cases this is not possible, owing to their remoteness. Von Baeyer,[1] in his well-known "tension theory," has shown that the series of methylene-ring hydrocarbons, $(CH_2)_n$, may be expected to possess a maximum of stability in the pentamethylene ring, a ring in which there is the least "strain," because the attraction of the carbon atoms for each other acts very nearly in the direction which the valences naturally assume, a deduction which has been confirmed by recent work on the reduction of aromatic hydrocarbons, showing the tendency of these to form pentamethylene rings when reduced.[2]

The speculations of Wislicenus and von Baeyer admit of application to the series of acids derived from the phosphonitrilic chlorides, and as far as the subject has been worked out the analogy is a complete one. The acids in the open form are amides of imidophosphoric acids; those with from 3 to 6 phosphorus atoms have the open form in alkaline solution, from which they are thrown out by silver nitrate as salts of the general formula $(PNO_2Ag_2)_n + H_2O$, but in acid solution they spontaneously form the inner anhydrides; i. e., the metaphosphimic acids, which can be precipitated as silver salts of the general formula $(PNO_2HAg)_n$. The acid with 7 phosphorus atoms, on the contrary, does not form the anhydride under any conditions. Not only does the series possess an extremely marked maximum of stability in tetrametaphosphimic acid, but the higher acids, on being subjected to energetic attack, break up, yielding this body.

In previous chapters I have assumed that tri- and tetrametaphosphimic acids contain phosphorus-nitrogen rings:





We know nothing of the steric relations of phosphorus and but little of those of nitrogen, and have therefore no definite theoretical grounds for assuming the magnitude of the angle a formed by the lines joining a POOH group with two NH groups, nor of the angle b formed by lines connecting a NH group with two POOH groups, in the case when these are free to assume a relation of greatest stability or least tension, as in an open chain. Neither can we assert that in a 6-sided ring, P_3N_3, with alternate phosphorus and nitrogen, the angles a and b must each be 120°. We are, however, justified in assuming that the *mean* of a and b is 120°. Similarly in an 8-sided ring, P_4N_4, the *mean* angle is 135°, even though a may be 180° and b 90°.

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[1] Ber. Deutsch. chem. Gesell., Berlin, Vol. XVIII, p. 2277.

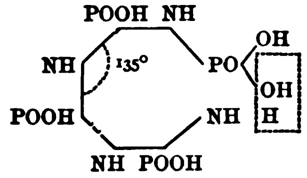
[2] Zelinsky, Ber. Deutsch. *chem. Gesell., Berlin*, Vol. XXX, pp. 387, 1539.

Experiment having shown that tetrametaphosphimic acid, $P_4N_4O_8H_8$, is vastly more stable than any other acid of the series, we may regard the angle $\frac{a+b}{2}$ of the octagonal nucleus P_4N_4, which is 135°, as that which most nearly coincides with the angle of least tension in the sense of von Baeyer's theory, and as approximating to that which would be assumed in an open chain, and we may expect that the stability of each ring will be less the more the angle $\frac{a+b}{2}$ differs from 135°. In the following table the mean angle and its difference from 135° are shown:

Ring.	Number of sides.	Mean angle.	Difference from 135°.
		Degrees.	*Degrees.*
PN	2	0	−135
P_2N_2	4	90	− 45
P_3N_3	6	120	− 15
P_4N_4	8	135	0
P_5N_5	10	144	+ 9
P_6N_6	12	150	+ 15
P_7N_7	14	154.3	+ 19.3
P_8N_8	16	157.5	+ 22.5

It is therefore to be expected that as we ascend in the series there will be a very rapid increase of stability to a maximum, followed by a gradual decrease. This coincides with what we find. $P_3N_3O_6H_6$ is vastly less stable than $P_4N_4O_8H_8$; the latter may be heated for hours with acids without complete decomposition, while the former is destroyed under the same conditions in a few minutes. $P_5N_5O_{10}H_{10}$ is much less stable than $P_4N_4O_8H_8$, but markedly more stable than $P_3N_3O_6H_6$, corresponding to the difference of only 9° from 135° in one case against 15° in the other. $P_6N_6O_{12}H_{12}$ is perceptibly less stable than $P_5N_5O_{10}H_{10}$, and finally the ring P_7N_7 of heptametaphosphimic acid is incapable of existence under the usual conditions, and as a result we get, instead of the ring acid $P_7N_7O_{14}H_{14}$, the open chain $P_7N_7O_{15}H_{16}$.

When any of the acids above tetrametaphosphimic acid is broken up, the latter is formed in considerable amount. This may be explained in two ways: either the P_4N_4 nucleus exists as such in the higher acid, or it is formed from the decomposition products. The former is highly improbable, for, considering its great stability, it should persist and be found in nearly theoretical amount, which is by no means the case. ($P_5N_5O_{10}H_{10}$ gave 12 per cent and $P_6N_6O_{12}H_{12}$ 30 per cent of the theoretical.) Its formation from the decomposition products is easily explained on the tension hypothesis. If a ring of POOH and NH groups be broken up by the action of a stronger acid, the molecules resulting from its decomposition will tend to assume a configuration determined by the mean angle of least tension, 135°, and this configuration in the case of the molecule of amido-triimidotetraphosphoric acid will be either a zigzag line or the form represented by



a configuration which admits of the formation of the anhydride or lactam, which is nothing else than tetrametaphosphimic acid. A theoretical yield of this can not be expected, for when a chain, P_5N_5, for example, is further broken up, the disruption may occur at any one of nine points, but only when one of the resulting products contains P_4N_4 can tetrametaphosphimic acid be formed. A simple calculation shows that at most only 27 per cent of that required by the equation

$$P_5N_5O_{10}H_{10} + 2H_2O = P_4N_4O_8H_8 + NH_4H_2PO_4$$

can be expected. A chain P_6N_6, however, offers more chances for the formation of fragments containing P_4N_4, and hence, as actually found, the yield of tetrametaphosphimic acid is greater, instead of less, as would be the case if the nucleus of this acid existed as such in hexametaphosphimic acid.

The first two chloronitrides, $PNCl_2$ and $P_2N_2Cl_4$, have not been obtained, and of the corresponding mono- and dimetaphosphimic acids the former is unknown and the existence of the latter questionable. Mente[1] has described salts of an acid to which he gives the formula of dimetaphosphimic acid, $P_2N_2O_4H_4$, but no proof is given that it is not some other polymer of PNO_2H_2, and the method by which he obtained it is one which is not likely to give a body of this molecular weight. The dimetaphosphimic ring would have a mean angle of 90°, which differs from that of tetrametaphosphimic acid by 45°. Such a ring should be much less stable than even that of heptametaphosphimic acid, and it is therefore quite possible that it is incapable of existence as such, and can exist only as the hydrate $P_2N_2O_5H_6$. This is perhaps the acid described by Gladstone[2] as pyrophosphodiamic acid.

The chloronitride series presents a maximum of stability in triphosphonitrilic chloride, but this is by no means as marked as that existing in the acid series. That such a maximum should occur in one case in a ring of 6 sides, and in the other in an 8-sided ring, and that the series should be limited in one case and unlimited in the other, involves no contradiction. Triphosphonitrilic chloride is stable only in the sense that it is formed in the largest amount and that its chlorine

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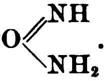
[1] Ann. Chem. (Liebig), Vol. CCXLVIII, p. 244.

[2] Quart. Jour. Chem. Soc. London, Vol. III, pp. 135, 354; Ann. Chem. (Liebig), Vol. LXXVI, p. 79; Vol. LXXVII, p. 315; *Jour. Chem. Soc. London [2]*, Vol. II, p. 231.

is most tenaciously held, while the term is applied to the acids as indicating the difficulty with which the ring is broken open. In the one case, the series consists of polymers of $—PCl_2=N—$ and in the other of $—POOH—NH—$, and the two series can not therefore be considered analogous in a stereochemical sense.

Only tri- and tetrametaphosphimic acids give characteristic salts. The salts of the acids with 5, 6, and 7 atoms of phosphorus are totally devoid of crystallizing power, the alkaline salts being precipitated from aqueous solution by alcohol as sirups, which can easily be converted into the solid form by dehydration with absolute alcohol, but which are still wholly amorphous. The tendency to diminished acidity of unneutralized hydroxyls, well known in the case of orthophosphoric acid, is here apparent, and to an increasing extent as we rise in the series. Trimetaphosphimic acid forms a salt with 3 atoms of sodium which has neutral reaction and is not decomposed by strong acetic acid; tetrametaphosphimic acid readily gives salts with 2 and 4 atoms of sodium. The 5-atom sodium salt of pentametaphosphimic acid is strongly alkaline and shows a tendency to hydrolytic dissociation, and the same tendency is still more marked in the higher acids. Owing to this and to their amorphous nature it is impossible to obtain salts of definite composition from any but the first two acids unless certain conditions are rigidly adhered to. Qualitative differences between the analogous salts of the higher acids are almost wanting, and only a quantitative study and a knowledge of their derivation serve to distinguish them. As with other phosphorus-nitrogen acids, no ammonia is evolved on boiling with alkalies.

Amides of the metaphosphimic acids.—Gerhardt[1] has described, under the name "phosphamide," a body of the empirical composition PN_2OH_3, which he obtained by action of ammonia and water on phosphorus pentachloride and to which he gave the formula  $PO\begin{smallmatrix}\diagup NH\\ \diagdown NH_2\end{smallmatrix}$. This corresponds to the amide of a metaphosphimic acid, but its properties indicate that it is probably a substance of high molecular weight. I have attempted to obtain amides of the first three metaphosphimic acids by acting on the corresponding chloronitrides with gaseous or strong aqueous ammonia. The efforts were but partially successful. The P:N ratio is sometimes rather higher, sometimes rather lower, than is required by the formula $(PN_2OH_3)_n$. They have none of the properties of Gerhardt's phosphamide, but are extremely soluble in water, uncrystallizable, and unstable, and have weakly acid properties, forming alkali and silver salts, which, however, are of very variable composition and of ill-defined properties. Like the metaphosphimic acids, they give off no ammonia on boiling with alkali, but are easily decomposed on treatment with acids.

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[1] Ann. Chim. Phys. [3], Vol. XVIII, p. 188.

GENERAL SUMMARY.

The principal results of the preceding investigations may be summed up as follows:

1. There exists a series of bodies of the general formula $(PNCl_2)_n$, beginning with Liebig's chloronitride of phosphorus, and extending indefinitely upward.

2. Each of these bodies yields, on saponification, an acid with the same number of phosphorus and nitrogen atoms.

3. The first four of these acids exist in two forms—the lactam form, $(PNO_2H_2)_n$ (metaphosphimic acids), where *n* is either 3, 4, 5, or 6, which is formed only in neutral or acid solution, and the open-chain form $(PNO_2H_2)+H_2O$, formed under the influence of alkalies.

4. The acid derived from the fifth chloronitride, $P_7N_7Cl_{14}$, and possibly those from the higher members, do not form lactams, but persist in the open form under all circumstances.

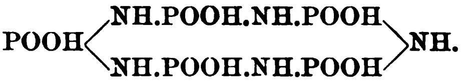
5. The properties of these acids with respect to stability, power of forming lactams, and nature of decomposition products may be explained by stereochemical considerations, analogous to those of von Baeyer on the methylene hydrocarbons and of Joh. Wislicenus on the lactones.

EXPERIMENTAL PART.

Saponification of the phosphonitrilic chlorides.—As pointed out in the preceding papers, triphosphonitrilic chloride is conveniently saponified by shaking its ethereal solution with an aqueous solution of sodium acetate, and tetraphosphonitrilic chloride in a similar manner with water, the trifling quantities of secondary decomposition products being easily removed. These methods can not be applied to the higher chlorides, for the secondary products formed by the liberated acetic or hydrochloric acid can not be separated from the main product owing to the uncrystallizable nature of the latter. A smooth saponification without secondary products may be effected by using sodium hydroxide in sufficient amount to keep the solution always strongly alkaline.

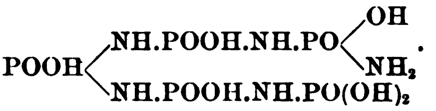
Four parts chloride are dissolved in about 20 parts alcohol-free ether and shaken with a solution of 5 parts pure sodium hydroxide in 20 parts water. A bottle with a carefully paraffined glass stopper must be used, corks being inadmissible, as they give rise to colored products which can not be removed. The shaking is conveniently effected by a rotator, moved by a small electric motor, and about fifty hours are sufficient for complete saponification. As soon as the ether is found to be practically free from chloronitrides, the alkaline solution is drawn off and precipitated by 2 or 3 volumes of alcohol. This throws down the sodium salt as a thick sirup, which is repeatedly washed by stirring with 60 per cent alcohol, dissolved in water, reprecipitated by alcohol, and again washed in the same way until it is free from sodium chloride. It is then dehydrated by stirring, kneading, and finally pulverizing under renewed portions of absolute alcohol. After standing several hours under absolute alcohol it is filtered off and dried in vacuo over sulphuric acid. The yield in each case is about 90 per cent of the theoretical, the remainder being lost in the alcoholic solution.

Pentametaphosphimic Acid.



$$\mathrm{POOH}\Big\langle\begin{array}{l}\mathrm{NH.POOH.NH.POOH}\\ \mathrm{NH.POOH.NH.POOH}\end{array}\Big\rangle\mathrm{NH}.$$

This is the lactam of *amidotetrimidopentaphosphoric acid*,



$$\mathrm{POOH}\Big\langle\begin{array}{l}\mathrm{NH.POOH.NH.PO}\Big\langle\begin{array}{l}\mathrm{OH}\\ \mathrm{NH_2}\end{array}.\\ \mathrm{NH.POOH.NH.PO(OH)_2}\end{array}$$

It exists in the lactam form in the 5-atom silver salt and apparently in the solution of its acid and normal salts; in alkaline solutions, however, it has probably the open form, as the silver salt prepared from such a solution has a composition corresponding to this.

The free acid may be obtained, somewhat contaminated with decomposition products, by decomposing the silver salt under water by hydrogen sulphide, care being taken to keep the liquid cool. The solution has an acid, somewhat astringent, taste, and is imperfectly precipitated by alcohol in a gelatinous form, resembling precipitated alumina. This shows the reaction of the salts, but is impure, as caustic alkali causes the evolution of little ammonia.

Sodium salts.—As all the sodium salts are amorphous and precipitated by alcohol, in a sirupy or viscous form, it is not easy to obtain any of them pure. The salt prepared in the above manner contains about 5.4 atoms of sodium (analyses 1 and 2) and forms a white, sandy, amorphous powder, which is not hygroscopic, but which slowly absorbs carbon dioxide. Under water it first becomes pasty and then slowly dissolves, with considerable evolution of heat. Salts with 4 or more atoms of sodium invariably contain 2 molecules of water which are retained at 100°.

The penta-sodium salt, $P_5N_5O_{10}H_5Na_5+2H_2O$, may be obtained by adding to the solution of a salt containing a known excess of sodium nearly enough nitric acid to neutralize the excess and precipitating by alcohol, or by nearly neutralizing with acetic acid, with phenolphthalein as indicator, and precipitating by alcohol. In the latter case, however, there is a slight deficiency of sodium (analyses 3 and 4). The normal salt has a strongly alkaline reaction and loses some alkali by repeated precipitation by alcohol.

For analysis the salts were dried at 100°.

	Calculated for $P_5N_5O_{10}H_5Na_5+2H_2O$.	Found.			
		1.	2.	3.	4.
P	28.64	28.23	28.24	29.10	29.13
N	12.96	12.90	12.86	13.29	13.22
Na	21.27	22.74	22.64	21.54	20.77

1 and 2 were precipitated directly from alkaline solution.

1. P:N:Na=5:5.02:5.42.
2. P:N:Na=5:5.03:5.40.

3 and 4 were precipitated from a solution neutralized with acetic acid with phenolphthalein as indicator.

3. P: N: Na=5: 5.03: 4.75.
4. P: N: Na=5: 5.02: 4.80.

The tetra-sodium salt, $P_5N_5O_{10}H_5.Na_4H+2H_2O$, is obtained by dissolving the crude salt in water with its own weight of 80 per cent acetic acid and precipitating twice by alcohol. It resembles the normal salt, but has neutral reaction.

It gave after drying at 100°:

	Calculated for $P_5N_5O_{10}H_5.Na_4H+2H_2O$.	Found.
P	29.85	30.02
Na	17.74	17.71

P: Na=5: 3.97.

Salts with still less alkali can be obtained by precipitating the crude salt by alcohol from a nitric acid solution. This precipitate is viscous rather than sirupy, as with the salts with 4 and 5 atoms of sodium. Salts with 5 or more atoms of sodium can be kept indefinitely without alteration and do not evolve ammonia with alkalies, but those with less gradually decompose.

Barium salt.—A solution of the sodium salt gives, with barium chloride, a voluminous precipitate of unknown composition, insoluble in water and acetic acid.

Magnesium salts.—Pentametaphosphimic acid forms several salts with magnesium alone, as well as double salts with magnesium and other metals.

A solution of the sodium salt, strongly acidified with acetic acid, gives, with magnesium salts, a voluminous, amorphous precipitate, nearly insoluble in water and but slightly more soluble in strong acetic acid. The composition of this, after drying at 100°, approximates to $P_5N_5O_{10}H_5.Mg_2H+5H_2O$.

	Calculated for $P_5N_5O_{10}H_5.Mg_2H+5H_2O$.	Found.	
		1.	2.
P	29.26	28.82	29.05
Mg	9.16	9.52	10.10

1. P : Mg = 5 : 2.11.
2. P : Mg = 5 : 2.22.

A considerable portion of the acid remains in solution, however, even in the presence of a large excess of the precipitant, in combination with less than 2 atoms of magnesium, and can be precipitated by alcohol as a salt soluble in water. If this insoluble magnesium salt be dissolved in dilute nitric acid and ammonia added to incipient precipitation, the solution, after filtering, contains essentially the primary salt $(P_5N_5O_{10}H_9)_2Mg$; from this solution silver nitrate throws down an amorphous magnesium silver salt with a varying amount of silver. The primary salt is easily soluble in water and is remarkably stable, giving no precipitate with ammonia, sodium hydroxide or carbonate, even on boiling. The magnesium can be removed only by adding to its solution ammonia and an alkaline phosphate. On boiling in neutral or acetic acid solution, however, a precipitate of the 2-atom salt at once forms. Even the latter dissolves in boiling sodium carbonate solution.

Indications of an intermediate salt were observed, but it could not be isolated in pure condition.

Silver salts.—The silver salts of the phosphorus-nitrogen acids are invariably free from water, and it is upon these, therefore, that the formulas of the acids themselves are based. There is no difficulty in obtaining normal silver tri- and tetrametaphosphimates of theoretical composition, and their crystalline nature affords a guaranty of their homogeneity. The same difficulty is encountered with the silver pentametaphosphimates, however, as with the sodium salts; they are amorphous flocculent precipitates, the composition of which corresponds to a definite formula only when they are formed under special conditions. In this case, as in others in this paper, the actual percentage composition expresses very little, if compared with the calculated composition of a definite salt. It is therefore better to express the results of the analysis in a molecular formula based on the atomic ratios of phosphorus, nitrogen, and silver, as actually determined; a comparison of the percentage composition found, with that calculated for salts of the lactam and open chain acids containing phosphorus and silver in the same ratio, then shows at once to which of these acids the salt is to be referred.

The composition of the precipitates depends altogether on the *relative amounts of* the reacting bodies; and even the free acid can be almost completely precipitated, provided a sufficient excess of silver nitrate be used. The preparations analyzed were made by precipitating a solution of 1 gram sodium salt in 50 cubic centimeters water with 55 cubic centimeters one-fifth normal silver nitrate solution. To the sodium salt was added enough nitric acid to produce a salt of known composition. Under these conditions it was found that a salt with 4 atoms of sodium gives very nearly the normal salt, $P_5N_5O_{10}H_5Ag_5$ (analyses 3, 4, 6), the number of equivalents of silver in the precipitate always exceeding the number of equivalents of sodium. Up to 5 atoms of silver the precipitates are white; with more silver they become more and more yellow in proportion to the amount of silver they contain. An excess of 0.3 atom over the normal imparts a perceptible yellow tint. The salts are unaffected by light or by heating at 100°, and are decomposed by cold caustic alkalies[1] with separation of silver oxide.

In the following table the molecular formulas given are based on the ratio of phosphorus to silver actually determined and referred to the acids $P_5N_5O_{10}H_{10}$ and $P_5H_5O_{11}H_{12}$. A comparison shows that the salts are derivatives of the former, a true metaphosphimic acid. The salts were dried at 100°.

	Ratio P : N : Ag.		P.	N.	Ag.
1	5 : 5.02 : 5.18	$P_5N_5O_{11}H_{6.82}Ag_{5.18}$	16.03	7.26	57.80
		$P_5N_5O_{10}H_{4.82}Ag_{5.18}$	16.34	7.39	58.88
		Found	16.31	7.41	58.76
2	5 : 5.06 : 5.32	$P_5N_5O_{11}H_{6.68}Ag_{5.32}$	15.79	7.15	58.45
		$P_5N_5O_{10}H_{4.68}Ag_{5.32}$	16.09	7.28	59.55
		Found	16.04	7.35	59.37
3	5 : 5.04 : 4.95	$P_5N_5O_{11}H_{7.05}Ag_{4.95}$	16.45	7.45	56.66
		$P_5N_5O_{10}H_{5.05}Ag_{4.95}$	16.77	7.59	57.77
		Found	16.75	7.64	57.69
4	5 : 4.96 : 4.96	$P_5N_5O_{11}H_{7.04}Ag_{4.96}$	16.45	7.45	56.66
		$P_5N_5O_{10}H_{5.04}Ag_{4.96}$	16.77	7.59	57.77
		Found	16.77	7.53	57.82
5	5 : 5.04 : 5.15	$P_5N_5O_{11}H_{6.85}Ag_{5.15}$	16.09	7.28	57.65
		$P_5N_5O_{10}H_{4.85}Ag_{5.15}$	16.40	7.42	58.75
		Found	16.32	7.45	58.46
6	5 : 5.05 : 4.97	$P_5N_5O_{11}H_{7.03}Ag_{4.97}$	16.42	7.43	56.78
		$P_5N_5O_{10}H_{5.03}Ag_{4.97}$	16.74	7.57	57.89
		Found.	16.62	7.59	57.51

Tri- and tetrametaphosphimic acids, when precipitated from ammoniacal solution by excess of silver nitrate, gave amorphous yellow salts

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[1] $P_3N_3O_6H_3Ag_3$ is scarcely affected by boiling with strong caustic potash and $P_4N_4O_8H_4Ag_4$ is scarcely affected in the cold, but is at *once decomposed on boiling.*

of the composition $P_3N_3O_7H_2Ag_6$ and $P_4N_4O_9H_2Ag_8$ respectively.[1] These are salts of the open-chain acids. A similar salt is obtained by precipitating an ammoniacal solution of pentametaphosphimic acid by silver nitrate, but in accordance with its less acid properties the quantity of silver does not reach 10 atoms, being in the specimen analyzed only 8.76 atoms, but the figures correspond closely to a derivative of amidotėtrimidopentaphosphoric acid, $P_5N_5O_{11}H_{12}$, rather than pentametaphosphimic acid. Dried at 100° it gave:

Ratio P : Ag.		P.	Ag.
5 : 8.76	$P_5N_5O_{11}H_{3.24}Ag_{8.76}$	11.49	70.04
	$P_5N_5O_{10}H_{1.24}Ag_{8.76}$	11.64	70.98
	Found	11.48	70.03

It appears, therefore, that in alkaline solution the metaphosphimic acids become open-chain acids, just as lactones and lactams give γ- and δ-oxy- and amido-acids. On drying at 100°, the yellow silver salts become gray without loss of weight, probably owing to separation of silver oxide. This is perhaps due to a tendency to revert to the lactam form, with separation of silver oxide, rather than water.

DECOMPOSITION OF PENTAMETAPHOSPHIMIC ACID.

Pentametaphosphimic acid is markedly more stable in acid solution than trimetaphosphimic acid. In the section on the latter I described in detail its decomposition products when acted on by nitric acid. Under identical conditions the rate of decomposition of pentametaphosphimic acid was found to be very much slower. On account of this greater stability the action of hot acetic acid gives more satisfactory results. No attempt was made to isolate all the products, as these are numerous and the analytical difficulties considerable. The following were identified:

Tetrametaphosphimic acid, $P_4N_4O_8H_8$.
Triimidotetraphosphoric acid, $P_4N_3O_{10}H_9$.
Diimidotriphosphoric acid, $P_3N_2O_8H_7$.
Orthophosphoric acid, H_3PO_4.

Five parts sodium pentametaphosphimate are dissolved in 15 parts water, 5 parts strong acetic acid added, and the solution heated in the water bath. The separation of a crystalline precipitate of acid sodium tetrametaphosphimate begins in about fifteen minutes and continues for perhaps eight hours, at the end of which time the solution gives no precipitate with magnesium chloride, indicating the absence of pentametaphosphimate. The sodium tetrametaphosphimate, being insoluble in a solution of sodium salts, is completely precipitated. It is filtered off and washed a little with saturated sodium acetate solution. The

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[1] In the third section of this paper the formula $P_4N_4O_8Ag_8$ was ascribed to the per-silver salt of tetrametaphosphimic acid; a recalculation of the analyses in the above manner, however, shows that they correspond much more closely to the open form $P_4N_4O_9H_2Ag_8$, with a slight deficiency of silver.

filtrate is concentrated to about one-half with addition of about 5 parts solid sodium acetate, whereby sodium triimidotetraphosphate separates, in the form of flat prisms or plates, which are washed with a little saturated sodium acetate solution and purified by dissolving in water and precipitating by alcohol, or by adding solid sodium acetate to their hot solution. On further concentrating the filtrate, large plates are often obtained, which give, with silver nitrate and nitric acid, a crystalline precipitate of the characteristic silver diimidotriphosphate, $P_3N_2O_8H_4Ag_3$. No satisfactory and certain method can be given for the separation of these two acids.

The *sodium tetrametaphosphimate* thus obtained usually has the form of spindles, but, when well developed, consists of brilliant double pyramids. It had not been observed at the time of writing the paper on tetrametaphosphimic acid. It is obviously an acid sodium salt, as it is formed only in the presence of acetic acid or a limited amount of a stronger acid. It was also obtained directly from the original sample of the acid, but was not analyzed, as it is difficult to obtain a sufficient quantity uncontaminated by the free acid. It is moderately soluble in water, but almost insoluble in solutions of sodium salts and is highly characteristic of this acid. The crude salt was dissolved in ammonia, with the addition of some ammonium nitrate, and precipitated by nitric acid as $P_4N_4O_8H_6(NH_4)_2$. The precipitation is almost quantitative. This pure salt was dissolved in ammonia, largely diluted, and, after acidifying with nitric acid, precipitated by an excess of silver nitrate in the form of the characteristic $P_4N_4O_8H_4Ag_4$. This gave:

	Calculated for $P_4N_4O_8H_4Ag_4$.	Found.
P	16.68	16.88
N	7.55	7.56
Ag	58.03	57.51

The free acid was obtained by decomposing the silver salt with hydrochloric acid in the characteristic form of difficultly soluble needles. It gave:

	Calculated for $P_4N_4O_8H_8+2H_2O$.	Found.
P	35.22	35.08
N	15.94	15.75

A comparison of the acid potassium, sodium, and ammonium salts and neutral ammonium salt with those prepared from a sample of tetrametaphosphimic acid from tetraphosphonitrilic chloride showed them to be identical in form. The yield of tetrametaphosphimic acid appears to be nearly independent of proportions and concentration, and was about 12 per cent of that required by the equation

$$P_5N_5O_{10}H_{10} + 2H_2O = P_4N_4O_8H_8 + NH_4H_2PO_4.$$

Triimidotetraphosphoric acid, $PO(OH)_2.NH.POOH.NH.POOH.NH.PO(OH)_2$.—The sodium salt of this, the third member of the imidophosphoric acid series obtained, crystallizes well in small rhombic or six-sided plates. The several specimens obtained were not analyzed, but converted into the silver salt. By analogy with $P_3N_2O_8H_7$, there can be little doubt that it is the acid salt, $P_4N_3O_{10}H_5Na_4$. It is easily soluble in water, but almost insoluble in saturated sodium acetate solution or dilute alcohol. It gives a precipitate with magnesium nitrate only on adding ammonia and ammonium chloride, when a voluminous precipitate is obtained, which, on standing, slowly changes to minute crystalline spherules.

Silver triimidotetraphosphate, $P_4N_3O_{10}H_5Ag_4$, is obtained as a voluminous amorphous white precipitate by adding silver nitrate to a solution of the sodium salt faintly acidified with nitric acid. On long standing under its mother-liquor it becomes crystalline and this change occurs in a few moments on washing the precipitate, shrinking to a heavy, sandy, crystalline powder, a very characteristic behavior. The same change can be observed under the microscope in the partially washed salt, the amorphous portion changing to minute particles showing active Brownian movement, which aggregate to prisms which are long and pointed and often tufted at the ends, and which can not be distinguished in appearance from silver tetrametaphosphimate. From a decidedly acid solution the salt is deposited slowly and without the intermediate amorphous form.

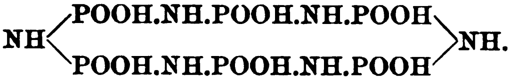
The salt gave after drying at 100°:

	Calculated for $P_4N_3O_{10}H_5Ag_4$.	Found.	
		1.	2.
P	16.26	16.43	16.48
N	5.52	5.62	5.55
Ag	56.58	56.61	57.18

1. P : N : Ag = 4 : 3.03 : 3.96.
2. P : N : Ag = 4 : 2.98 : 3.99.

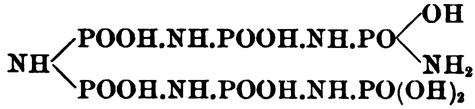
Triimidotetraphosphoric acid could not be obtained from tetrametaphosphimic acid, being much less stable than the latter. It is therefore probably derived from the breaking down of the chain of phosphorus and nitrogen atoms formed by the hydrolysis of the pentametaphosphimic ring.

Hexametaphosphimic Acid.



$$\mathrm{NH}\left\langle\begin{array}{l}\mathrm{POOH.NH.POOH.NH.POOH}\\\mathrm{POOH.NH.POOH.NH.POOH}\end{array}\right\rangle\mathrm{NH.}$$

This is the lactam of *amidopentimidohexaphosphoric acid*,



$$\mathrm{NH}\left\langle\begin{array}{l}\mathrm{POOH.NH.POOH.NH.PO}\left\langle\begin{array}{l}\mathrm{OH}\\\mathrm{NH_2}\end{array}\right.\\\mathrm{POOH.NH.POOH.NH.PO(OH)_2}\end{array}\right.$$

It is obtained as sodium salt by saponifying hexaphosphonitrilic chloride in ethereal solution by sodium hydroxide in the manner above described. In neutral or acid solution it has the lactam form, as shown by the composition of the silver salt, but in alkaline solution it has presumably the open form. The free acid, obtained in solution by decomposing the silver salt under water by hydrogen sulphide, has an astringent rather than acid taste, and can not be obtained pure in the solid form, as it is not precipitated by alcohol, and the solution, on evaporating, undergoes much decomposition, leaving a gummy residue.

Sodium hexametaphosphimate, $P_6N_6O_{12}H_6Na_6 + 2H_2O$.—The properties of this salt are essentially the same as those of the corresponding pentametaphosphimate. When containing an excess of alkali it is stable, but with a deficiency it decomposes more or less rapidly. A salt of approximately normal composition can be obtained by adding to the solution of a preparation with more than 6 atoms of sodium enough nitric acid to neutralize the excess and precipitating by alcohol (analyses 3 and 4). In the following table the results are expressed in formulas based on the determined ratio P : Na. The samples were dried at 100°.

	Ratio P : N : Na.		P.	N.	Na.
1	6 : 6.02 : 6.35	$P_6N_6O_{12}H_{5.65}Na_{6.35}+2H_2O$	28.62	12.95	22.50
		Found	28.55	12.96	22.45
2	6 : : 6.46	$P_6N_6O_{12}H_{5.54}Na_{6.46}+2H_2O$	28.51	....	22.80
		Found	28.31	....	22.63
3	6 : 6.04 : 5.93	$P_6N_6O_{12}H_{6.07}Na_{5.93}+2H_2O$	29.02	13.14	21.31
		Found	29.13	13.27	21.38
4	6 : 6.05 : 5.94	$P_6N_6O_{12}H_{6.06}Na_{5.94}+2H_2O$	29.02	13.14	21.31
		Found	29.16	13.29	21.43
5	6 : : 4.60	$P_6N_6O_{12}H_{7.40}Na_{4.60}+2H_2O$	31.05	....	17.70
		Found	30.89	....	17.60

1 and 2 precipitated from solution containing excess of alkali; 3 and 4, from solution in which excess over 5 Na had been neutralized; 5, from solution in large excess of acetic acid.

Magnesium salt.—A solution of the sodium salt precipitated by magnesium nitrate in the presence of acetic acid, under exactly the same conditions as were observed in preparing the corresponding pentametaphosphimate, gave a salt which closely resembles the latter, but which does not approximate to any definite formula (found P : Mg = 6 : 2.43). The precipitation is by no means complete, much remaining in solution as a salt which can be precipitated by alcohol, which is not decomposed by boiling with alkalies, and which, in general, resembles the primary salt of pentametaphosphimic acid.

Silver hexametaphosphimate, $P_6N_6O_{12}H_6Ag_6$.—The silver salt prepared from the sodium salt varies in composition with the relative amounts of the reacting bodies and with the amount of sodium. It was obtained of normal composition by dissolving 1 gram sodium salt in 50 cubic centimeters water, adding enough nitric acid to produce a salt with 5.75 atoms of sodium, and precipitating by 50 cubic centimeters one-fifth normal silver nitrate (analyses 3 and 4). It resembles the corresponding pentametaphosphimate, but is somewhat more gelatinous. Any excess of silver over 6 atoms tends to give it a yellow color. It is decomposed in the cold by caustic potash with separation of silver oxide. The analyses given in the following table of preparations dried at 100° show that it is derived from the true hexametaphosphimic acid, $P_6N_6O_{12}H_{12}$.

	Ratio P : N : Ag.		P.	N.	Ag.
1	6 : 6.08 : 5.65	$P_6N_6O_{13}H_{8.35}Ag_{5.65}$	16.97	7.68	55.60
		$P_6N_6O_{12}H_{6.35}Ag_{5.65}$	17.26	7.81	56.53
		Found	17.23	7.89	56.48
2	6 : : 6.21	$P_6N_6O_{13}H_{7.79}Ag_{6.21}$	16.09	....	57.97
		$P_6N_6O_{12}H_{5.79}Ag_{6.21}$	16.35	....	58.89
		Found	16.29	....	58.64
3	6 : 5.99 : 5.98	$P_6N_6O_{13}H_{8.02}Ag_{5.98}$	16.44	7.44	57.02
		$P_6N_6O_{12}H_{6.02}Ag_{5.98}$	16.71	7.56	57.95
		Found	16.70	7.54	57.90
4	6 : 6.04 : 6.02	$P_6N_6O_{13}H_{7.98}Ag_{6.02}$	16.38	7.41	57.18
		$P_6N_6O_{12}H_{5.98}Ag_{6.02}$	16.65	7.54	58.02
		Found	16.57	7.54	57.80

A yellow salt is obtained by precipitating the ammoniacal solution by silver nitrate.

Decomposition of hexametaphosphimic acid.—The sodium salt heated with acetic acid gives tetrametaphosphimic acid, which was isolated in the manner described above. The yield is 30 per cent of that required by

$$P_6N_6O_{12}H_{12} + 4H_2O = P_4N_4O_8H_8 + 2NH_4H_2PO_4.$$

After purifying, it was converted into the silver salt, which gave:

	Calculated for $P_4N_4O_8H_4Ag_4$.	Found.
P	16.68	16.63
N	7.55	7.50
Ag	58.03	57.58

P : N : Ag = 4 : 3.99 : 3.98.

Comparison of the crystals of free acid and of the acid and neutral ammonium salts, acid potassium salt, neutral sodium salt, and silver salt with similar preparations made from tetraphosphonitrilic chloride showed that they were identical.

The decomposition products were not further studied.

AMIDOHEXIMIDOHEPTAPHOSPHORIC ACID, $P_7N_7O_{15}H_{16}$.

The saponification of heptaphosphonitrilic chloride is effected in the usual manner with sodium hydroxide. As before pointed out, this acid does not give the lactam, heptametaphosphimic acid, even in acid solution, the silver salt having the composition of a salt of the open-chain acid.

Sodium salt.—The properties of this salt are similar to those of sodium penta- and hexametaphosphimate. Dried in vacuo and at 100°, it gave:

	Calculated for $P_7N_7O_{15}H_{8.57}Na_{7.43} + 2H_2O$.	Found.
P	28.16	28.31
Na	22.19	22.31

P : Na = 7 : 7.43.

Silver salt, $P_7N_7O_{15}H_9Ag_7$.—To obtain a salt of normal composition, 1 gram sodium salt is dissolved in 50 cubic centimeters water, enough nitric acid is added to form a salt with 6.85 atoms of sodium, and precipitated by 50 cubic centimeters one-fifth normal silver nitrate. More sodium or silver nitrate gives a salt richer in silver. The salt forms a white semigelatinous precipitate, which dries in vacuo to translucent brittle lumps, which were pulverized, dried again in vacuo and then carefully to constant weight at 100°.

	Ratio P : N : Ag.		P.	N.	Ag.
1	7 : : 6.93	$P_7N_7O_{15}H_{9.07}Ag_{6.93}$	16.55		56.99
		$P_7N_7O_{14}H_{7.07}Ag_{6.93}$	16.77		57.77
		Found	16.44		56.61
2	7 : : 7.21	$P_7N_7O_{15}H_{8.79}Ag_{7.21}$	16.17		57.97
		$P_7N_7O_{14}H_{6.79}Ag_{7.21}$	16.40		58.76
		Found	16.21		58.09
3	7 : : 7.08	$P_7N_7O_{15}H_{8.92}Ag_{7.08}$	16.35		57.51
		$P_7N_7O_{14}H_{6.92}Ag_{7.08}$	16.57		58.30
		Found	16.27		57.27
4	7 : 7.04 : 7.03	$P_7N_7O_{15}H_{8.97}Ag_{7.03}$	16.41	7.43	57.35
		$P_7N_7O_{14}H_{6.97}Ag_{7.03}$	16.64	7.53	58.16
		Found	16.35	7.44	57.14

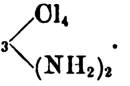
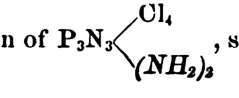
These figures show beyond question that the acid has the open form $P_7N_7O_{15}H_{16}$.

The decomposition of the sodium salt by acetic acid gives rise to a considerable amount of tetrametaphosphimic acid, characterized by its crystalline form and that of its salts.

HIGHER ACIDS.

Of the higher acids of the series but little can be said. The oil remaining over from preparation of chloronitrides, and which has a mean molecular weight nearly corresponding to $P_{11}N_{11}Cl_{22}$, on saponification gives a mixture of sodium salts which are precipitated by alcohol in a decidedly viscous form, and which are decomposed by acids, giving tetrametaphosphimic, diimidotriphosphoric, and triimidotetraphosphoric acids. They were not further investigated.

AMIDES OF METAPHOSPHIMIC ACIDS.

Amides of $P_3N_3O_6H_6$.—Strong ammonia gas acts slowly on a solution of $P_3N_3Cl_6$ in absolute ether, the product being at first ammonium chloride and the chloramide,  $P_3N_3\begin{cases}Cl_4\\(NH_2)_2\end{cases}$. This remains in solution and is gradually attacked further, but is the only product of the reaction which is soluble in ether; by further action of ammonia the chlorine is further substituted, but never completely, and the reaction product is thrown down, mixed with ammonium chloride. On washing this with alcohol, dissolving in water, and treating with enough silver nitrate to precipitate the chlorine, a solution is obtained which, by fractional precipitation with silver nitrate, gave the silver salt of an amide with the ratio P : N : Ag = 3 : 6.27 : 2.01. An ethereal solution of  $P_3N_3\begin{cases}Cl_4\\(NH_2)_2\end{cases}$, shaken with sodium hydroxide, gives the sodium salt of the diamide of trimetaphosphimic acid, from which the chlorine may be removed by neutralizing with nitric acid and adding the calculated amount of silver nitrate. From the filtrate an amorphous silver salt may be precipitated which gave the ratio $P : N : Ag = 3 : 4.88 : 3.51$. If $P_3N_3Cl_6$, $P_4N_4Cl_8$, or $P_5N_5Cl_{10}$ in ethereal solution is shaken with ammonia of sp. gr. 90, a strong reaction occurs at first, whereby a portion of the chlorine is replaced. On shaking two or three hours, the remainder is removed. The excess of ammonia was removed from the aqueous solution by blowing air through and the chlorine precipitated by the theoretical amount of silver nitrate. The ammonium salts of the amides thus obtained were thrown down by alcohol as sirups which can not be hardened under absolute alcohol. If these solutions are precipitated by silver nitrate, after adding a little ammonia, amorphous white precipitates of the amido silver salts are obtained, which do not show a constant composition. Analysis gave the following atomic ratios:

$$\text{Amide from } P_3N_3Cl \text{ — } P : N : Ag = \begin{cases} 3 : 5.80 : 2.20 \\ 3 : 5.96 : 3.36 \\ 3 : 6.54 : 3.08 \end{cases}$$

$$\text{Amide from } P_4N_4Cl_8 \text{ — } P : N : Ag = \begin{cases} 4 : 8.80 : 4.82 \\ 4 : 9.28 : 4.03 \end{cases}$$

$$\text{Amide from } P_5N_5Cl_{10} \text{ — } P : N : Ag = 5 : 10.16 : 2.64$$

From these figures it appears that the amides are of very varying composition. As they are amorphous and very unstable, it is unlikely that any definite bodies can be obtained in this way. The silver salts are turned yellow by potassium hydroxide, a portion of the amide going into solution and a salt with a higher proportion of silver being formed.

ON A HYDROMICA FROM NEW JERSEY.

By F. W. CLARKE and N. H. DARTON.

While studying the Juratrias formation in New Jersey, one of us (Darton) found in an old "trap" quarry at Rocky Hill a hydromica, which occurred under such novel conditions that it appeared to be worthy of investigation. It is found in veins of calcite, mainly as a thin coating, and adjacent to the diabase of the vein walls. The latter consist of more or less decomposed rock, of which the principal product is a soft, dark-green chloritic material. In portions of the vein the mica extends down the cleavage planes into the masses of calcite. A considerable amount of the calcite was thrown out during the quarrying operations, but only a portion of it is covered with the mica. This portion presents the appearance of having been coated with bronze paint.

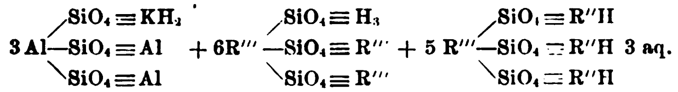
The mica occurs in minute flakes thinly matted together. Its color is golden bronze, although some portions are slightly greenish. The mineral is soft, and thinly foliated. Under the microscope it exhibits no definite crystalline form; and its optical properties, although not distinctive, suggest biotite. It appears to be biaxial, but with a very small axial angle, and it is pleochroic. When heated, it does not exfoliate. It fuses before the blowpipe, at a moderately high temperature, to a dark-colored bead. The specific gravity was not determined. It is readily decomposable by hydrochloric acid. The analysis, by Mr. George Steiger, of material not free from calcite is subjoined. In the second column of figures the reduced analysis is given, titanic oxide and calcite being thrown out, soda recalculated to terms of potash, and the whole adjusted to 100 per cent.

	Found.	Reduced.	Ratios.
SiO_2	32.72	40.24	.671
TiO_2	.24	....	....
Al_2O_3	8.41	10.34	.101
Fe_2O_3	19.99	24.57	.154
FeO	4.24	5.21	.072
CaO	10.30	....	....
MgO	5.51	6.78	.166
K_2O	.85	2.20	.024
Na_2O	.63	....	....
CO_2	8.21	....	....
H_2O at 100°	2.47	3.03	.168
H_2O above 100°	6.22	7.63	.424
	99.79	100.00	....

This gives, as an orthosilicate, the formula

$$(KH)_{68}(MgFe)_{24}(AlFe)_{51}(SiO_4)_{67}.\quad 28H_2O.$$

It is evident, from these data, that the mica is one which has been largely, but not wholly, altered to a vermiculite; the latter term indicating a mica in which potassium has been replaced by hydrogen, and which has taken up water of crystallization. So far as the analysis goes, the condition of the water is uncertain; for it was determined in two fractions only, at and above 100°, whereas more fractions are needed for accurate diagnosis. Some crystalline water may be retained far above 100°, so that the loss above that temperature includes part of this fraction plus all the water of constitution. Apart from this uncertainty the ratios reduce easily in terms of the mica theory to the following molecular mixture:



$$3\,Al\begin{cases}SiO_4\equiv KH_2\\ SiO_4\equiv Al\\ SiO_4\equiv Al\end{cases} + 6R'''\begin{cases}SiO_4\equiv H_3\\ SiO_4\equiv R'''\\ SiO_4\equiv R'''\end{cases} + 5\,R'''\begin{cases}SiO_4\equiv R''H\\ SiO_4\equiv R''H\\ SiO_4\equiv R''H\end{cases} 3\ aq.$$

Calculating with the atomic ratios Al : Fe''' : : 2 : 3, and Fe'' : Mg : : 3 : 7, we have the following comparison between analysis and theory:

	Reduced.	Calculated.
SiO_2	40.24	40.55
Al_2O_3	10.34	10.51
Fe_2O_3	24.57	24.71
FeO	5.21	5.21
MgO	6.78	6.75
K_2O	2.20	2.27
H_2O, 100°	3.03	a 4.34
H_2O, above 100°	7.63	b 5.66
	100.00	100.00

a Crystalline. b Constitutional.

In short, the mica consists of muscovitic and phlogopitic molecules in the ratio of 9 : 5.

$$9\ R'''_3(SiO_4)_3R'_3,$$
$$5\ R'''(SiO_4)_3R''_3H_3,\ 3\ aq.$$

The mineral is evidently an unusual mica, differing widely from any other hitherto described. Its very high proportion of ferric oxide is its chief characteristic, and suggests a ferric muscovite as one of the antecedent, unaltered molecules. Such a muscovite is theoretically conceivable, but is not actually known.

THE ALKALINE REACTION OF SOME NATURAL SILICATES.

By F. W. Clarke.

That pure water exerts a distinct solvent action upon many natural silicates has long been known. As far back as 1848 the Rogers brothers published a series of observations upon this subject,[1] and showed that some species of minerals would give an alkaline reaction to test paper. They did not, however, give details concerning the individual minerals thus investigated. The more recent researches of Daubrée and of Cossa are well known.

By the use of phenolphthalein as an indicator the alkalinity of many silicates can be demonstrated with the utmost ease, and the experiments described below serve to bring out very clearly the relative decomposability of certain minerals and rocks by pure water. The method adopted was as follows: A series of glass-stoppered bottles was placed against a white background. In each bottle half a gram of finely pulverized mineral was put, and then 50 cubic centimeters of distilled water, containing a very little alcoholic phenolphthalein, was added. As the indicator was mixed, once for all, with the total amount of water taken for the entire series, the 22 samples examined were treated exactly alike. Two of the bottles were filled with the water and indicator in blank, in order that possible action upon the glass itself might be detected if it occurred. The two blanks, however, remained colorless during the two weeks through which the experiments lasted. The results obtained were as follows:

Muscovite.—A doubtful trace of coloration, which soon disappeared.

Lepidolite.—Like muscovite.

Phlogopite.—The peculiar nonfluoriferous variety from Edwards, New York. Gave a very distinct, permanent pink coloration.

Orthoclase.—A trace of coloration which increased for a few days and then faded.

Oligoclase.—The transparent variety from Bakersville, North Carolina. Distinct and permanent, but pale coloration.

Albite.—From Amelia County, Virginia. Gave a good, permanent, alkaline reaction.

Leucite.—A slight reaction at first, which faded in a few days.

Nephelite.—The elæolite from Litchfield, Maine. Good coloration, but partly fading in time.

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[1] Am. Jour. Sci., 2nd series, Vol. V, p. 401.

Cancrinite.—Litchfield, Maine. Gives a deep rose coloration, which is permanent.

Sodalite.—From Canada. A deep, permanent rose color.

Spodumene.—The transparent, yellow variety from Brazil. A good reaction, but gradually fading.

Scapolite.—The wernerite from St. Lawrence County, New York. Gave a faint, evanescent trace of coloration.

Laumontite.—A doubtful trace of coloration.

Stilbite.—Faint, evanescent coloration.

Chabazite.—Like stilbite.

Heulandite.—Slight reaction, but distinct.

Thomsonite.—Variety lintonite. A fairly strong reaction, fading in time.

Analcite.—Good alkaline reaction.

Natrolite.—From Bohemia. Strong coloration, permanent.

Pectolite.—From Bergen Hill. Gave a very deep rose color.

Apophyllite.—From Bergen Hill. A very deep rose color.

In nearly every case the reaction was obtained at once, showing a more rapid action of water upon the silicate than had been anticipated. In some instances fading is noted. This is doubtless due, in general, to the action of light, but in certain cases the colored solution separated into two layers, the color being wholly in the lower. Here the color was really held as a coating upon the fine solid particles, and as they subsided the appearance of stratification was produced. Toward the end of the experiments the mineral aegirite was added to the series. This also gave a strong alkaline reaction and a fairly deep rose color.

A neat method of demonstrating the reactions described above is the following: Place a little of the mineral to be tested in a watch glass upon a sheet of white paper. Add a drop of alcoholic phenolphthalein solution, and then a few drops of pure water; in most cases the reaction is given instantaneously. Orthoclase gave no coloration, leucite a trace, and scapolite a trace; albite, nephelite, and phlogopite furnished distinct reactions. Under the same circumstances thomsonite, aegirite, natrolite, cancrinite, sodalite, pectolite, and apophyllite gave immediately a deep, rich, rose color. The strongest alkaline reactions seemed to be given by pectolite and apophyllite.

In general the order of intensity of the color produced was what might have been expected. Among the micas, muscovite and lepidolite showed little or no solubility, while phlogopite was distinctly attacked. In nature the magnesian micas are far more easily alterable than muscovite, a fact which is reiterated by these experiments. Again, orthoclase was slightly dissolved, albite much more so, and oligoclase gave a reaction between the two; that is, more than the one, less than the other. In other words, the plagioclase feldspars alter more easily than orthoclase, as is apparent in the study of the rocks themselves.

In order to bring out the latter point more clearly, a series of rocks which had been analyzed in the laboratory of the United States Geological Survey was placed in a row of bottles and treated, just as the mineral species had been, with water and phenolphthalein. A granite and an amphibole-gabbro gave no alkaline reaction. A rhyolite, trachyte, leucite-basalt, feldspar-basalt, and diorite gave faint traces of color. Granitite, gneiss, phonolite, diabase, and camptonite yielded distinct alkaline colorations.

In all of these instances the production of color is doubtless due to the solution from the mineral or rock of alkaline silicates. The noteworthy point is the quickness with which the reaction can be obtained. With minerals like cancrinite, sodalite, natrolite, pectolite, and apophyllite, the reaction is striking enough to be used as a lecture-table experiment.

THE SOLUBILITY IN WATER OF CERTAIN NATURAL SILICATES.

By George Steiger.

The results cited in the preceding paper are purely qualitative in character. The following experiments are analogous in kind, but are aimed at putting the subject on a quantitative basis. In both investigations the same samples of material were employed, so that the data are fairly comparable.

The work was carried out as follows: One-half gram of each of the finely ground minerals was weighed out, and placed in a 2-ounce bottle with 50 cubic centimeters of water. These bottles were set aside where the temperature remained about 70° F. for one month, and were skaken from time to time. At the end of the period all were filtered, and the solutions were titrated with a standard hydrochloric acid solution, methyl-orange being used for an indicator.

What has gone into solution by this treatment I can not say—sometimes soda, sometimes potash, possibly sometimes lime, but for the sake of comparison the results in the following table have been calculated in terms of Na_2O; although the percentage of sodium is very small in some of the specimens. I have given also in another column the percentage of the combined alkalies as shown by analysis of specimens from the same localities.

	Formula.	Per cent of combined alkalies by analysis.	Equivalent of Na_2O in solution.
Pectolite, Bergen Hill, N. J	$Ca_2(SiO_3)_3NaH$	9.11	0.57
Muscovite	$Al_3(SiO_4)_3KH_2$	10.00	.32
Natrolite, New Jersey	$Al_2(SiO_4)_3Na_2H_4$	15.79	.30
Lintonite, Lake Superior	$Al_6(SiO_4)_6(CaNa_2)_3.7H_2O$	5.92	.29
Phlogopite, Edwards, N. Y	$Al(SiO_4)_3Mg_3KH_2$	9.32	.22
Laumonite	$Al_2SiO_4Si_3O_8Ca.4H_2O$	1.00	.18
Lepidolite, Maine	$KHLiAl_3(SiO_4)_3$ $K_3Li_3(AlF_2)_3Al(Si_3O_8)_3$	13.00	.18
Elæolite, Litchfield, Me	$Al_3(SiO_4)_3Na_3$	21.17	.16
Heulandite, Nova Scotia	$Al_6(Si_3O_8)_6(CaNa_2)_3.16H_2O$	2.00	.13
Orthoclase	$KAlSi_3O_8$	16.00	.11

	Formula.	Per cent of combined alkalies by analysis.	Equivalent of Na_2O in solution.
Analcite	$NaAl(SiO_3)_2.H_2O$	14.00	.10
Oligoclase, Bakersville, N. C.	$AlNaSi_3O_8$ $Al_2CaSi_2O_8$	9.18	.09
Albite	$AlNaSi_3O_8$	12.10	.07
Wernerite, St. Lawrence County, N. Y.	$Ca_4Al_6Si_6O_{25}$ $Na_4Al_3Si_9O_{24}Cl$	11.09	.07
Leucite, Vesuvius, Italy	$KAl(SiO_3)_2$	21.39	.06
Stilbite, Nova Scotia	$Al_2(Si_3O_8)_2(CaNa_2).6H_2O$	1.00	.05
Chabazite, Nova Scotia	$Al_2SiO_4Si_3O_8(CaNa_2).6H_2O$	7.10	.05

It is worth noting in comparing the depth of color produced by phenolphthalein solution, as shown in Professor Clarke's paper, with the percentage of alkali in solution as shown in this work, that some of the minerals which give a deep coloration with the former, show in the above table a comparatively small amount of alkali in solution, and vice versa. Muscovite, for example, while giving only a faint coloration with phenolphthalein, contains in solution alkaline compounds equivalent to 0.49 per cent K_2O; pectolite, with 0.57 per cent Na_2O, being the only one of the series showing a larger amount. The cause of these discrepancies remains to be ascertained.

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BULLETIN

OF THE

UNITED STATES

GEOLOGICAL SURVEY

No. 168

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

ANALYSES OF ROCKS

FROM THE

LABORATORY OF THE UNITED STATES GEOLOGICAL SURVEY

1880-1899

TABULATED BY

F. W. CLARKE

CHIEF CHEMIST

WASHINGTON
GOVERNMENT PRINTING OFFICE
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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., February 27, 1900.

SIR: I submit herewith the manuscript for a revised and enlarged edition of Bulletin No. 148, entitled Analyses of Rocks, etc. Dr. Hillebrand's portion of the former bulletin is so much extended, and represents so distinct a demand, that it will be presented by him as a separate bulletin.

Very respectfully,
F. W. CLARKE,
Chief Chemist.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

ANALYSES OF ROCKS, LABORATORY OF THE UNITED STATES GEOLOGICAL SURVEY, 1880-1899.

By F. W. Clarke.

INTRODUCTION.

The present Geological Survey of the United States was organized in 1879. In 1880 a chemical laboratory was established at Denver, in connection with the Colorado work, in charge of Dr. W. F. Hillebrand, with whom were associated Mr. Antony Guyard and, later, Mr. L. G. Eakins. In 1882 Dr. W. H. Melville was placed in charge of a second laboratory at San Francisco, and in the autumn of 1883 the central laboratory was started in Washington, with myself as chief chemist. In November, 1885, Dr. Hillebrand was transferred to Washington; early in 1888 he was followed by Mr. Eakins, and the Denver laboratory was discontinued. In the spring of 1890 Dr. Melville also was transferred to Washington, and since then the chemical work of the Survey has been concentrated at headquarters.

Up to January 1, 1900, nearly 4,400 analyses have been made in the laboratory at Washington. These represent rocks, minerals, ores, waters, sediments, coals, metals, and so on through all the range of substances with which geology has to do. There were also some hundreds of analyses made in the laboratories at Denver and San Francisco. A fair amount of research work upon mineralogical and analytical problems has also been done. In all of this work the following chemists have been employed: Charles Catlett, T. M. Chatard, F. W. Clarke, L. G. Eakins, F. A. Gooch, Antony Guyard, W. F. Hillebrand, W. H. Melville, R. B. Riggs, E. A. Schneider, George Steiger, H. N. Stokes, William Valentine, and J. E. Whitfield. As many as eight of these have been at work simultaneously; at present only four are connected with the Survey. Other officers of the Survey have been occupied more or less with chemical questions; but the men named in this list were connected directly with the laboratory. Some work for the chemical division has also been done by chemists not regularly on the rolls of the Survey; but their analyses, with the exception of a single group to be noted later, do not fall within the scope of this paper.

Quite naturally, on account of the activity of the petrographers, the dominant feature of the laboratory work has been the analysis of rocks. These have been studied in great numbers and in the most thorough way. The results have appeared in widely scattered publications, official reports, monographs, bulletins, American and foreign journals, and so on. The object of this bulletin is to bring together this valuable material, together with such bibliographic and petrographic data as seems to be necessary in order to identify the specimens and to facilitate chemical discussion. Analyses of minerals have been included only when related to petrographic studies, appearing then in connection with the rocks to which they belong. Meteorites, of which twenty-seven have been analyzed, are brought into the work on account of their petrographic relations; and the groups of clays and soils have been admitted because of the bearing of these substances upon the study of slates and shales. The actual number of analyses given in the bulletin is as follows:

Igneous and crystalline rocks	854
Mineral separations	90
Meteorites, and separations from them	58
Sandstones, cherts, and sinters	48
Carbonate rocks	208
Slates and shales	48
Clays, soils, etc	98
Total	1,404

It may be observed that the classification thus indicated has not been rigorously followed. In a few instances the study of a sedimentary rock has been so related to that of its igneous neighbors that the analyses are best tabulated together; but these exceptional cases are few, and all are properly noted. The heading "igneous and crystalline rocks" has been used in the broadest and most liberal way, and doubtless many of the analyses given under it might properly be otherwise classified. In such cases of uncertainty, convenience has furnished the rule to follow.

Within each division of the analyses the classification chosen has been geographic. The petrographic grouping of the rocks would doubtless be best were petrographers agreed upon it; but their differences are many, and the chemist will do well to avoid them. The geographic method, moreover, has some advantages of its own; it facilitates the study of areas, it simplifies the bibliographic references, and it brings together, in great measure, the work of each petrographer for whom analyses have been made. Thus, most of Diller's work has been in California, most of Cross's in Colorado, and most of Iddings's in the Yellowstone National Park, and in each case the analyses are massed, and their discussion is practically uniform in character. As regards nomenclature, each rock has received the designation given it by its describer, and no liberties have been taken. This plan may cause some lack of uniformity; but no other procedure seemed to be practicable.

It will be noticed by anyone who uses this bulletin that the analyses vary as regards completeness. Among the sedimentary rocks, especially, partial analyses are common; but in the igneous group thoroughness is more general. In the early days of the chemical division many analyses were made along the older lines, just as they are still made in many laboratories to-day—that is, only the main constituents, those having direct petrographic significance, were determined. In such analyses the minor ingredients, like titanium, phosphorus, barium, strontium, chlorine, etc., were ignored; and, although the results are satisfactory in some respects, they leave much to be desired. Latterly, greater completeness has been sought for, the work done has been much fuller, and the data obtained can be discussed with much higher approaches to accuracy. The old form of "complete analysis" is to be discouraged; it leads too often to erroneous conclusions; and only the best modern methods of work and of statement should be tolerated. The fuller analyses, moreover, have brought some interesting points to light; titanium now appears to be one of the more abundant elements, and barium and strontium are found to be almost universally diffused in igneous rocks in quite perceptible quantities.

On general principles the analysis of a rock and its petrographic description should be two parts of the same investigation, matching each other completely. In practice, however, this rule does not always hold, and the departures from it are in two opposite directions. For example, an analysis of the older type says nothing of titanium and phosphorus, while the microscope reveals the presence of sphene and apatite. In this case the petrographer has been more thorough than the chemist. On the other hand, a full and perfect analysis may be given, accompanied by a petrographic description of the most general kind, in which only the main mineral constituents of the rock are noted. Here the analysis has been incompletely used, and the petrographic discussion is defective. It is hoped that the publication of this material may lead to a clearer recognition of the mutuality which should exist between the chemical and the microscopic researches, and so bring, in the future, both lines of investigation more into harmony. Hitherto the chemist and the petrographer have worked too much apart, and each has too often misunderstood the purpose of the other. If the study of the thin section could always precede the analysis, the petrographic problems could be stated more clearly, and the chemical evidence might be rendered much more pertinent and satisfactory.

In a paper published some years ago,[1] on the relative abundance of the chemical elements, I computed the average composition of the primitive crust of the earth from 880 analyses of eruptive and crystalline rocks. Of these analyses only 207 were from the laboratories of the survey, while 673 were collected from various other American and foreign sources. A large proportion of them were incomplete, regarded from a modern point of view, and yet the results obtained were fairly conclusive. The material now available for similar discussion is much

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[1] *Bull. U. S. Geol. Survey No. 78*, 1891, p. 34.

better than that which was formerly used, and an average based upon it may not be out of place here.

In the bulletin now presented there are 830 complete analyses of rocks which are suitable for my purpose. I have also taken from the partial analyses given in the laboratory records 180 additional determinations of silica, 90 of lime, and 130 of alkalies. In 490 of the analyses there is discrimination between the water lost below 110° and that which is essential to the composition of the rocks; and this amounts to 0.40 per cent. Omitting this water, the average found may fairly represent the composition of the older crust of the earth, as deduced from a mass of data which are reasonably uniform in character and entitled to a high degree of credence. The mean for the more important constituents is as follows, with the old average given in a parallel column for comparison:

	New mean.	Old mean.
SiO_2	59.71	58.59
Al_2O_3	15.41	15.04
Fe_2O_3	2.63	3.94
FeO	3.52	3.48
CaO	4.90	5.29
MgO	4.36	4.49
K_2O	2.80	2.90
Na_2O	3.55	3.20
H_2O	1.52	[a] 1.96
TiO_2	.60	.55
P_2O_5	.22	.22
	99.22	99.66

[a] Including hygroscopic water; probably 0.40 per cent.

If we reduce these figures to elementary form and include the minor constituents which are frequently found in rocks, and which in this laboratory are often estimated, the two averages compare as follows:

	New mean.	Old mean.
Oxygen	47.02	47.29
Silicon	28.06	27.21
Aluminum	8.16	7.81
Iron	4.64	5.46
Calcium	3.50	3.77
Magnesium	2.62	2.68
Sodium	2.63	2.36
Potassium	2.32	2.40
Titanium	.41	.33
Hydrogen	.17	.21
Carbon	.12	.22
Phosphorus	.09	.10
Manganese	.07	.08
Sulphur	.07	.03
Barium	.05	.03
Strontium	.02	....
Chromium	.01	.01
Nickel	.01	....
Lithium	.01	....
Chlorine	.01	.01
Fluorine	.01	....
	100.00	100.00

As the old mean represents an attempt to measure the composition of the entire solid crust of the earth, and so includes an allowance for the carbon in the limestones, the two columns are not strictly comparable. They are, however, corroborative of each other, and show that within reasonable limits the statistical method is applicable to the problem under consideration. For the arguments upon which the discussion is based the original paper should be consulted. The distribution of the rarer elements has also been elaborately discussed by Vogt,[1] and their percentages may be regarded as small corrections to be applied to the table at some future time.

By a similar statistical process I have attempted to ascertain something with regard to the relative abundance of the more important rock-forming minerals. Nearly 500 analyses of igneous rocks were

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[1] Zeitsch. Prakt. Geologie, 1898, pp. 225, 314, 377, 413; and 1899, pp. 10, 274.

discussed, and the subjoined percentages, which are probably nothing more than rough approximations to the truth, were obtained:

Quartz	12.0
Feldspars	60.0
Pyroxenes and amphiboles	18.0
Micas	4.0
	94.0

The less frequent minerals make up the remaining 6 per cent. The computation, although it is by no means conclusive, is perhaps a little more satisfactory than any similar estimate which has so far been made.

For computing the average composition of the sedimentary rocks the existing analyses of individual samples are inadequate. They are too few and too incomplete to yield any conclusions of value. Attempts have been made to partly use the data, as, for example, by Joly;[1] and it seems probable, therefore, that better material will not be without interest or scientific value.

Some five years ago, at the request of Mr. G. K. Gilbert, a series of composite analyses of sedimentary rocks was made in this laboratory. Many samples were mixed into one uniform sample, from which, by a single analysis, an average composition was determined. The material was selected and the samples were prepared by Mr. Gilbert, assisted by Mr. G. W. Stose, and the analyses were made by Dr. H. N. Stokes. The data obtained may be tabulated as follows:

A. Composite analysis of 27 Mesozoic and Cenozoic shales. Each individual shale was taken in amount roughly proportional to the mass of the formation which it represented.

B. Composite analysis of 51 Paleozoic shales, weighted as in the former case.

C. General average of A and B, giving them, respectively, weights as 3 to 5. This average represents 78 rocks.

D. Composite analysis of 253 sandstones, about one gramme of each being taken in preparing the average sample.

E. Composite analysis of 371 sandstones used for building purposes. Equal weights taken.

F. Composite analysis of 345 limestones, equal weights being taken.

G. Composite analysis of 498 limestones used for building purposes, equal weights taken.

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[1] An estimate of the geological age of the earth: Sci. Trans. Royal Dublin Soc., vol. 7, p. 23, 1899.

	A.	B.	C.	D.	E.	F.	G.
SiO_2	55.43	60.15	58.38	78.66	84.86	5.19	14.09
TiO_2	.46	.76	.65	.25	.41	.06	.08
Al_2O_3	13.84	16.45	15.47	4.78	5.96	.81	1.75
Fe_2O_3	4.00	4.04	4.03	1.08	1.39	.54	.77
FeO	1.74	2.90	2.46	.30	.84	undet.	undet.
MnO	trace	trace	trace	trace	trace	.05	.03
CaO	5.96	1.41	3.12	5.52	1.05	42.61	40.60
SrO	none	none	none	trace	none	none	none
BaO	.06	.04	.05	.05	.01	none	none
MgO	2.67	2.32	2.45	1.17	.52	7.90	4.49
K_2O	2.67	3.60	3.25	1.32	1.16	.33	.58
Na_2O	1.80	1.01	1.31	.45	.76	.05	.62
Li_2O	trace	trace	trace	trace	trace	trace	trace
H_2O at 110°	2.11	.89	1.34	.31	.27	.21	.30
H_2O above 110°	3.45	3.82	3.68	[a]1.33	[a]1.47	[a].56	[a].88
P_2O_5	.20	.15	.17	.08	.06	.04	.42
CO_2	4.62	1.46	2.61	5.04	1.01	41.58	35.58
S	......	......	......	......	......	.09	.07
SO_3	.78	.58	.65	.07	.09	.05	.07
Cl	......	......	......	trace	trace	.02	.01
Carbon [b]	.69	.88	.81	......	......	......	......
	100.48	100.46	100.46	100.41	99.86	100.09	100.34

[a] Includes organic matter. [b] Of organic origin.

These analyses may be used for a variety of purposes. For example, they can help in tracing the change from an average igneous rock to an average sediment. They suggest something as to the characteristic features which distinguish a good building stone from other limestones and sandstones. They are applicable to the discussion of a variety of large theoretical problems, like that chosen by Professor Joly. These considerations alone justify their publication here.

In the former edition of this bulletin (No. 148) a chapter upon analytical methods, by Dr. W. F. Hillebrand, was included. For that chapter there has been a large separate demand, and for that reason it will be expanded into a work of greater detail and issued as a distinct bulletin. It will be noticed that to Dr. Hillebrand many of the best analyses in this compilation are due, and a full statement of methods, embodying his experience, will be of the utmost value.

During the preparation of this bulletin much assistance was rendered by the petrographers and geologists connected with the Survey, especially with reference to analyses hitherto unpublished. In each case credit has been given for the data thus added. Twenty-eight analyses of rocks from Montana, executed by or under the direction of Prof. L. V. Pirsson, of Yale University, and having been made in connection with regular Survey work, are included in the tabulations. With this exception all of the analyses given were made in the Survey laboratories. To those executed in the laboratory at Washington "record numbers" are attached, which serve to identify them on the record books of the Division of Chemistry. Of the abbreviations used for bibliographic reference only three need explanation, and they refer to the official publications of the Survey. "Ann." for Annual Report, "Mon." for Monograph, and "Bull." for Bulletin are the three in question. The others relate to well-known journals, and are familiar to all geologists. The letters P. R. C., following the description of a rock, refer to the Petrographic Reference Collection of the Survey, and are followed by the number assigned to the rock in that series.

ANALYSES.

IGNEOUS AND CRYSTALLINE ROCKS.

MAINE.

1. ROCKS FROM AROOSTOOK COUNTY.

Described by H. E. Gregory in Bull. 165. Analyses by W. F. Hillebrand, record No. 1795.

A. Quartz-trachyte (bostonite), Quoggy Joe Mountain, Presque Isle Township. Contains quartz, orthoclase, albite, and magnetite, with siderite, kaolin, and chlorite.

B. Teschenite, Mapleton Township. In dikes cutting shales. Contains andesine, augite, biotite, apatite, analcite, and magnetite.

C. Andesite, Edmunds Hill, Chapman Township. Contains labradorite, orthoclase, pyroxene, apatite, and magnetite.

D. Calciferous sandstone, New Sweden Township. Contains calcite, alkali, feldspar, quartz, magnetite, muscovite, and siderite. Included here because studied as one of the group.

	A.	B.	C.	D.
SiO_2	72.77	46.77	61.40	54.23
Al_2O_3	12.15	14.91	16.59	7.38
Fe_2O_3	.44	7.80	2.13	.54
FeO	3.06	4.90	3.05	1.37
MgO	.22	2.94	2.73	3.29
CaO	.07	6.30	6.17	14.56
Na_2O	3.38	4.97	3.83	1.65
K_2O	4.67	2.37	1.34	1.74
H_2O at 105°	.17	.92	.82	.25
H_2O above 105°	.55	4.28	.88	1.22
TiO_2	.20	2.31	.79	.28
P_2O_5	trace	.98	.20	.07
ZrO_2	.04	none	none	(?)
Cr_2O_3	none	none	trace	(?)
V_2O_3	(?)	.02	.02	(?)
FeS_2	.12	.07	none	(?)
NiO	none	trace	trace	none
MnO	.16	.29	.13	undet.
SrO	none	.03	trace?	none
BaO	.03	.04	.02	none
CO_2	2.06	trace?	none	13.48
	100.09	99.90	100.10	100.06

Traces of lithia present in all. F and Cl not looked for.

E. Diabase (basaltic glass), Mars Hill. Not resolvable into minerals.

F. Rhyolite, Haystack Mountain. Contains quartz in a groundmass of orthoclase.

G. Volcanic tuff, southeast base of Castle Hill. Contains fragments of trachyte, andesite, devitrified glass, and lapilli.

H. Diabase, Aroostook Falls, near Maine boundary line. Dike. Contains plagioclase, pyroxene, and pyrite.

	E.	F.	G.	H.
SiO_2	42.25	75.98	31.42	49.64
Al_2O_3	16.87	12.34	11.57	15.07
Fe_2O_3	5.24	.85	2.37	1.66
FeO	10.72	.93	7.48	8.82
MgO	6.91	.15	5.32	5.43
CaO	3.33	.13	16.71	7.23
Na_2O	3.96	4.02	2.26	4.19
K_2O	.77	4.44	.74	.89
H_2O at 105°	.43	.24	.76	.45
H_2O above 105°	5.58	.64	4.17	2.81
TiO_2	2.93	.17	2.30	2.32
P_2O_5	.34	.03	.46	.29
ZrO_2	none	.03	none	none
Cr_2O_3	.03	(?)	trace	trace
V_2O_3	.07	(?)	.06	.04
FeS_2	trace	none	.16	.79
NiO	.01	none	trace	trace
MnO	.40	trace?	.38	.25
SrO	none	trace?	none	.05
BaO	trace?	.07	.64	.02
CO_2	none	none	13.13	.32
	99.84	100.02	99.93	100.27

Traces of lithia present in all. Cl and F not looked for.

2. LITCHFIELDITE AND ASSOCIATED MINERALS.

A. Elæolite-syenite, var. litchfieldite, from Litchfield. Described by ayley in Bull. 150, p. 201; and in Bull. Geol. Soc. Amer., vol. 3, p. 231. ontains elæolite, two feldspars, and lepidomelane, with sodalite, canrinite, and zircon as accessories. Analysis by L. G. Eakins, record o. 1298. P. R. C. 77.

B. Albite from A. Sp. gr. 2.622.

C. Potash feldspar from A. Sp. gr. 2.56. Analyses B and C by V. H. Melville, record No. 1275. P. R. C. 77.

	A.	B.	C.
SiO_2	60.39	68.28	65.14
Al_2O_3	22.57	19.62	18.19
Fe_2O_3	.42	....	....
FeO	2.26	.23	.25
MgO	.13	.09	.16
CaO	.32	.31	.33
Na_2O	8.44	10.81	1.68
K_2O	4.77	.39	14.14
H_2O	.57	.09	.17
MnO	.08	....	....
	99.95	99.82	100.06

The minerals found in this rock were quite fully described by Clarke n Bull. 42, pp. 28–38. Analyses by F. W. Clarke.

D. Elæolite, dark gray.

E. Hydronephelite.

F. Lepidomelane. Contains no fluorine.

	D.	E.	F.
SiO_2	43.74	38.99	32.09
Al_2O_3	34.48	33.62	18.52
Fe_2O_3	....	....	19.49
FeO	....	....	14.10
MgO	trace	....	1.01
CaO	trace	.07	....
Na_2O	16.62	13.07	1.55
K_2O	4.55	1.12	8.12
H_2O	.86	12.98	4.62
MnO	....	....	1.42
	100.25	99.85	100.92

G. Sodalite, deep blue. P. R. C. 77.
H. Cancrinite, bright orange yellow. P. R. C. 77.
I. Cancrinite, pale yellow, cleavable.
J. Cancrinite, pale yellow, granular.

	G.	H.	I.	J.
SiO_2	37.33	36.29	35.83	37.22
Al_2O_3	31.87	30.12	29.45	28.32
Fe_2O_3		trace	trace	trace
MgO				.07
CaO		4.27	5.12	4.40
Na_2O	24.56	19.56	19.33	19.43
K_2O	.10	.18	.09	.18
H_2O	1.07	2.98	3.79	3.86
MnO		trace	trace	trace
CO_2		6.96	6.50	6.22
Cl	6.83			
	101.76	100.36	100.11	99.70
O=Cl	1.54			
	100.22			

NEW HAMPSHIRE.

A. Elæolite-syenite, Red Hill, Moultonboro. Described by Bayley in Bull. Geol. Soc. Amer., vol. 3, p. 231. Contains elæolite, augite, hornblende, biotite, sodalite, albite, and orthoclase, with accessory apatite, sphene, magnetite, and an occasional zircon. Fibrous decomposition products are also present. P. R. C. 203.

B. Mixed albite and orthoclase from A.

C. Nepheline (elæolite) from A. Analyses by W. F. Hillebrand, record No. 1321. The mixed nepheline and feldspar were treated with dilute hydrochloric acid, and the residue was extracted with sodium carbonate solution. C represents the soluble part, and B the insoluble.

D. Camptonite, Campton Falls. Analysis by L. G. Eakins, record No. 1298. Described by J. P. Iddings in Bull. 150, p. 239. Contains hornblende, plagioclase, orthoclase, augite, iron ore, biotite, apatite, pyrite, and a mineral which appears to be analcite. Also variable calcite, serpentine, and chlorite P. R. C. 92.

E. Quartz-porphyry, Pemigewasset. Analysis by Eakins, No. 1298.

	A.	B.	C.	D.	E.
SiO_2	59.01	66.85	45.31	38.45	65.02
Al_2O_3	18.18	19.50	32.67	19.68	17.93
Fe_2O_3	1.63	.13		4.01	4.69
FeO	3.65			11.15	.17
MgO	1.05	trace	.16	6.65	1.24
CaO	2.40	.11	2.00	9.37	1.34
Na_2O	7.03	7.44	12.60	2.77	3.04
K_2O	5.34	5.80	5.70	1.72	5.98
H_2O at 100°	.15			1.49	.86
H_2O above 100°	.50	.31	1.56		
TiO_2	.81				
P_2O_5	trace				
MnO	.03			trace	.11
SrO	trace				
BaO	.08	.07			
Li_2O	trace	none			
CO_2	.12			4.82	
	99.98	100.21	100.00	100.11	100.38

VERMONT.

1. ROCKS OF MOUNT ASCUTNEY.

Analyses by W. F. Hillebrand, record Nos. 1621, 1657. Samples received from T. A. Jaggar, jr. Petrographic data furnished by R. A. Daly.

A. Typical granitite. Contains quartz, orthoclase, plagioclase (microperthite), biotite, magnetite, sphene, apatite, and zircon.

B. Basic segregation in granitite. Contains biotite, hornblende, quartz, plagioclase, microperthite, much sphene and apatite, some magnetite and zircon.

C. Another sample of B.

D. Syenite. Contains hornblende, augite, orthoclase, microperthite, plagioclase, biotite, quartz, magnetite, sphene, apatite, and zircon.

E. Basic segregation in syenite. Contains hornblende, augite, microperthite, orthoclase, plagioclase, quartz, magnetite, zircon, and apatite.

F. Syenite-porphyry. Contains orthoclase, quartz, hornblende, magnetite, apatite, and zircon.

	A.	B.	C.	D.	E.	F.
SiO_2	71.90	56.01	59.27	65.43	56.51	73.03
Al_2O_3	14.12	[a]15.19	15.76	16.11	16.59	13.43
Fe_2O_3	1.20	2.34	2.07	1.15	1.35	.40
FeO	.86	4.89	3.57	2.85	6.59	1.49
MgO	.33	4.67	3.04	.40	2.52	.14
CaO	1.13	4.85	3.69	1.49	4.96	.79
Na_2O	4.52	5.66	5.63	5.00	5.15	4.91
K_2O	4.81	2.16	3.33	5.97	3.05	4.54
H_2O at 110°	.18	.36	.23	.19	.21	.18
H_2O above 100°	.42	.90	.74	.39	.71	.35
TiO_2	.35	1.13	1.12	.50	1.20	.30
P_2O_5	.11	.53	.42	.13	.41	.06
ZrO_2	.04	....	.04	.11	.04	.06
MnO	.05	.40	.37	.23	.24	.15
(NiCo)O	none	.03	trace	(?)	trace?	(?)
BaO	.04	trace?	trace?	.03	.03	trace
CO_2	.21	undet.	.30	trace?	.33	trace?
F	.06	undet.	.42	.08	.24	.08
Cl	.02	undet.	.03	.05	.07	.03
FeS_2	trace	.09	.07	.07	.06	.09
	100.35	99.21	100.10	100.18	100.26	100.03
Less O	.03		.19	.04	.11	.0[illegible]
	100.32		99.91	100.14	100.15	99.9[illegible]

[a] Including ZrO_2.

G. Syenite-porphyry. Contains orthoclase, plagioclase, microperthite, hornblende; quartz, augite, magnetite, biotite, apatite, and zircon.

H. Granite-porphyry. Composition like D, but with more quartz.

I. Basic segregation in H. Contains hornblende, green and brown augite, biotite, quartz, microperthite, magnetite, little apatite, and zircon.

J. Diorite. Contains hornblende, augite, biotite, plagioclase, titaniferous magnetite, sphene, zircon, and quartz.

K. Diorite. Composition like J.

L. Another sample of K.

	G.	H.	I.	J.	K.	L.
SiO_2	64.88	73.69	56.53	52.12	57.97	64.62
Al_2O_3	16.24	12.46	16.47	16.35	[a]17.28	16.46
Fe_2O_3	1.37	1.21	1.58	3.68	2.23	1.82
FeO	2.70	1.75	5.40	6.02	3.75	2.14
MgO	.89	.17	2.67	4.14	2.20	1.10
CaO	1.92	.36	4.90	7.25	4.33	2.39
Na_2O	5.00	4.47	5.59	3.65	4.31	4.57
K_2O	5.61	4.92	3.80	2.34	4.12	5.21
H_2O at 110°	.19	.14	.23	.25	.18	.13
H_2O above 110°	.46	.24	.60	.88	.57	.39
TiO_2	.69	.28	1.40	2.10	1.54	.81
P_2O_5	.13	.04	.27	.89	.64	.21
ZrO_2	.13	.14	.03	.02	....	.03
MnO	.14	.15	.20	.17	.15	.12
(NiCo)O	none	none	trace	trace	trace	none
BaO	.06	none	trace	.04	.07?	.03
CO_2	none	trace	.05	.07	.05	.11
F	.08	.05	.19	.03	.04	undet.
Cl	.04	.02	.07	.09	undet.	.05
FeS_2	none	none	trace	.24	.32	.19
	100.53	100.09	99.98	100.33	99.75	100.38
Less O	.04	.02	.09	.03	.02	.01
	100.49	100.07	99.89	100.30	99.73	100.37

[a] Including ZrO_2.

M. Basic segregation in diorite. Contains hornblende, augite, biotite, plagioclase, magnetite, apatite, zircon, and a little quartz.

N. Diabase. Contains plagioclase, augite, and magnetite.

O. Camptonite. Contains brown hornblende, plagioclase, a little augite, olivine, magnetite, and apatite.

P. Phyllite. Contains quartz, sericite, graphite?, magnetite, pyrite, rare orthoclase, plagioclase, sphene, and rutile.

Q. Microperthite-hornfels. Contains biotite, quartz, red garnet, corundum, magnetite, iolite, microperthite, and rarely pleonaste.

R. Cordierite-hornfels. Contains quartz, biotite, pleonaste, corundum, iolite, magnetite, plagioclase, red garnet, and epidote?.

	M.	N.	O.	P.	Q.	R.
SiO_2	55.28	49.63	48.22	90.91	58.35	45.30
Al_2O_3	17.23	14.40	14.27	4.18	21.30	30.51
Fe_2O_3	1.54	2.85	2.46	.22	.03	.24
FeO	6.23	8.06	9.00	1.27	6.41	8.80
MgO	2.69	7.25	6.24	.37	2.10	3.11
CaO	5.60	9.28	8.45	.22	.85	.90
Na_2O	5.42	2.47	2.90	.77	1.60	1.65
K_2O	2.12	.70	1.93	.58	5.63	4.84
H_2O at 110°	.20	.27	.28	.06	.31	.26
H_2O above 110°	.71	1.47	1.66	.74	.86	1.05
TiO_2	1.64	1.68	2.79	.28	.87	1.48
P_2O_5	.73	.25	.64	.05	.18	.12
ZrO_2	trace	trace?	.03	.02	none	none
MnO	.24	.17	.20	trace	.13	.20
(NiCo)O	(?)	.04	.03	none	.03	.02
BaO	.06	trace?	.04	trace	.05	.03
CO_2	.04	1.36	.15	.18		
C				.10	.40	.17
SO_3	none	none	none	none	none	.04
Cl	.07	.07	.10		.03	.04
F	.28	trace	.05	trace	(?)	.04
FeS_2	.07	.22	.36	.11	.58	1.07
	100.15	100.17	99.80	100.06	99.71	99.87
Less O	.13	.02	.04			
	100.02	100.15	99.76			

In these rocks the sulphur is all reckoned as pyrite, although pyrrhotite also is probably present. The carbonic acid represents either dolomite or siderite; not calcite. Traces of lithia and strontia occur in nearly all. Samples H, L, O, and Q contain traces of copper. In *N there is 0.03* V_2O_3, a supplementary determination by Hillebrand.

2. MISCELLANEOUS ROCKS.

A. Amphibolite, Guilford. Described by Emerson in Mon. XXIX. Contains hornblende needles, with albite and rutile. Analysis by L. G. Eakins, record No. 1326.

B. Granitoid gneiss, north of Lincoln's.

C. The same, west slope of Little Peco.

D. Chloritic granite, East Clarendon section.

E. Hornblende-granite, East Clarendon section.

Rocks B, C, D, and E collected by C. L. Whittle, but not described. Analyses by H. N. Stokes, record No. 1396.

	A.	B.	C.	D.	E.
SiO_2	49.16	71.02	69.97	67.33	52.60
Al_2O_3	16.43	15.00	14.90	16.20	18.45
Fe_2O_3	3.92	1.12	2.16	1.40	2.47
FeO	7.19	1.81	.96	2.73	6.11
MgO	8.19	.69	.37	1.31	4.22
CaO	9.21	.31	.45	2.81	7.55
Na_2O	3.70	2.48	2.85	3.15	3.24
K_2O	.41	5.79	6.54	2.14	1.12
H_2O	.45	1.14	.66	1.84	2.53
TiO_2	1.03	.35	.44	.80	1.11
P_2O_5	.16	.13	.12	.16	.20
Cr_2O_3	trace				
MnO	.23	trace	trace	trace	.23
BaO	.02	trace	.09	.05	
	100.10	99.84	99.51	99.92	99.83

MASSACHUSETTS.

1. ROCKS OF THE CONNECTICUT VALLEY.

Described by Emerson in Mon. XXIX.

A. Serpentine derived from salite, Osburn's soapstone quarry, Blandford.

B. Dark-green, oily serpentine, center of large Middlefield bed.

C. Enstatite, slightly altered, from Granville. For comparison with D.

D. Serpentine derived from enstatite, Granville.

Analyses A, B, and C by W. F. Hillebrand, record No. 1555. Analysis D by Geo. Steiger, No. 1536.

	A.	B.	C.	D.
SiO_2	40.77	38.62	54.04	37.82
Al_2O_3	1.16	.35	.52	.61
Fe_2O_3	3.56	3.44	1.51	7.92
FeO	1.47	3.99	3.90	1.15
MgO	39.37	40.61	34.40	37.94
CaO	none	.40	none	none
Na_2O	.14	.10	.08	trace
K_2O	.10	.08		
H_2O at 110°	.49	.36	.70	.75
H_2O above 110°	12.48	10.91	3.07	12.50
TiO_2	none	none	none	trace
P_2O_5	trace	trace	none	trace
Cr_2O_3	.28	.39	.14	.19
MnO	.09	.10	.11	....
NiO	.17	.21	.23	.45
CoO	....	....	....	.05
Li_2O	trace	trace	....	....
CO_2	none	.52	1.32	....
	100.08	100.08	100.02	99.38

E. Rich, dark-green serpentine, Rowe.

F. Black serpentine containing marmolite, Atwater's quarry, Russell.

G. Blackish-green serpentine containing much chromite. From "The Crater," North Blandford.

H. Gray, splintery serpentine, Chester.

Analyses by Steiger, record No. 1536.

	E.	F.	G.	H.
SiO_2	40.42	36.94	39.14	33.87
Al_2O_3	1.86	.50	1.18	.77
Fe_2O_3	2.75	6.04	4.46	2.81
FeO	4.27	1.94	3.14	4.25
MgO	35.95	38.35	41.45	38.57
CaO	.66	none	none	none
Na_2O	.16	none	none	none
K_2O				
H_2O at 100°	.21	.71	.34	.38
H_2O above 100°	10.51	12.07	9.48	7.00
TiO_2	none	trace	none	none
P_2O_5	trace	trace	.02	trace
Cr_2O_3	.28	.33	.33	.38
MnO	trace	trace	none	.04
NiO	.53	.40	.47	.33
CoO	trace	none	trace	
CO_2	1.44	1.85	none	10.82
SO_3	trace	.20	none	.20
FeS_2	.43	....	....	....
	99.47	99.33	100.01	99.42

I. Peridotite, Belchertown. Contains hornblende, pyroxene, biotite, olivine, and magnetite. Analysis by L. G. Eakins, record No. 1326.

J. Massive, coarse, altered diabase, Leverett. Contains saussuritic feldspar with black hornblende. Analysis by Eakins, record No. 1325.

K. Tonalite, South Leverett. Dark green, chloritic. Contains reddish feldspar, dark hornblende, and a network of dark-green epidotic quartz veins. Analysis by Eakins, record No. 1326.

L. Biotite-granite, Moore's quarry, Florence. Very feldspathic. Quartz rare, with fluid inclusions. Feldspar mostly triclinic, orthoclase and microcline present in small quantities. Little muscovite, some rutile. Analysis by Eakins, record No. 1414.

	I.	J.	K.	L.
SiO_2	48.63	51.56	55.51	73.27
Al_2O_3	5.32	14.82	16.51	15.51
Fe_2O_3	2.91	4.30	1.68	.33
FeO	3.90	7.21	4.57	1.14
MgO	21.79	7.36	6.73	.15
CaO	13.04	7.09	6.73	2.74
Na_2O	.34	4.21	3.19	4.79
K_2O	.23	.17	2.46	1.66
H_2O	2.81	1.47	1.53	.68
TiO_2	.47	1.97	.91	.10
P_2O_5	.21	.09	.17	trace
Cr_2O_3	.36	....	....	....
MnO	.12	trace	.11	trace
BaO	trace	trace	.02	....
CO_2	trace	....	....	....
	100.13	100.25	100.12	100.37

M. Amphibolite, Bernardston. A black, heavy, massive hornblende rock. Analysis by L. G. Eakins, record No. 1327.

N. Porphyritic amphibolite, Heath. Analysis by Eakins, record No. 1325.

O. Amphibolite, New Salem. Analysis by Eakins, record No. 1325.

P. Amphibolite, Whitmans Ferry, Sunderland. Thin, shaly, aphanitic. Analysis by Eakins, record No. 1325.

	M.	N.	O.	P.
SiO_2	51.72	51.38	45.48	49.86
Al_2O_3	16.51	18.01	19.43	15.50
Fe_2O_3	1.72	3.30	.13	2.99
FeO	9.56	8.53	6.58	8.01
MgO	6.58	5.08	11.08	7.79
CaO	8.89	6.27	10.66	8.89
Na_2O	2.74	5.34	2.28	3.26
K_2O	.34	.18	.11	.72
H_2O	.51	.56	3.17	1.51
TiO_2	1.39	1.07	.77	1.58
P_2O_5	.23	.18	.14	.11
Cr_2O_3			trace	
MnO	trace	.19	trace	.07
BaO	trace	trace	.01	trace
CO_2			.20	
	100.19	100.09	100.04	100.29

Q. Amphibolite, South Leverett. Deep green, ligniform. Analysis by L. G. Eakins, record No. 1327.

R. Amphibolite, Goshen. Derived from Conway limestone. Analysis by Eakins, record No. 1414.

S. Black, fissile amphibolite, Worthington. Nearly pure, matted hornblende. Titanite and sometimes zircon present. Analysis by Eakins, record No. 1326.

T. Black, fissile, porphyritic amphibolite, Warwick. Analysis by Eakins, record No. 1414. Collected by Emerson, but not described in Monograph XXIX.

	Q.	R.	S.	T.
SiO_2	47.56	55.64	48.53	50.65
Al_2O_3	16.13	16.27	16.35	13.03
Fe_2O_3	1.80	1.22	2.03	.27
FeO	9.39	7.20	10.52	12.67
MgO	9.21	5.58	9.71	16.96
CaO	6.67	9.23	9.83	1.73
Na_2O	2.52	.91	1.36	1.37
K_2O	1.58	.19	.32	.04
H_2O	3.51	3.11	.79	2.96
TiO_2	1.24	.50	.51	.50
P_2O_5	.21	.23	.07	trace
Cr_2O_3	trace	....	....	trace
MnO	.08	.28	.17	.15
BaO	trace	....	trace	....
	99.90	100.36	100.19	100.33

2. MISCELLANEOUS ROCKS.

Collected by B. K. Emerson and unpublished at the date of writing.

A. Wehrlite, New Braintree. Contains diallage, enstatite, augite, anorthite, biotite, apatite, chromite, magnetite, and pyrrhotite. Analysis by L. G. Eakins, record No. 1327

B. Black, serpentinized boltonite, Stow. Analysis by W. F. Hillebrand, record No. 1555.

C. Highly metamorphosed feldspathic conglomerate, graduating into arkose-gneiss, electric railroad cut, Marlboro. Analysis by George Steiger, record No. 1536.

D. Phonolite, Southboro. No description furnished. Analysis by H. N. Stokes, record No. 1653. Contains traces of chlorine and fluorine; 63.2 per cent of the rock is decomposable by hydrochloric acid.

	A.	B.	C.	D.
SiO_2	50.64	36.92	75.35	54.22
Al_2O_3	7.93	.10	13.03	20.20
Fe_2O_3	1.41	1.19	.62	2.35
FeO	14.82	.87	.94	1.02
MgO	18.58	43.99	.21	.29
CaO	3.41	.59	1.33	.70
Na_2O	.96	.05	2.44	9.44
K_2O	.21		5.14	4.85
H_2O at 100°	.87	.72	.15	.42
H_2O above 100°		14.70	.73	5.57
TiO_2	.82	none	.21	.38
P_2O_5	.27	trace	.08	.11
Cr_2O_3	.05	none	....	none
MnO	.16	trace	none	.19
BaO	....	none	.07	trace
CO_2	....	.90	.03	trace
SO_3	....	....	.03	none
	100.13	100.03	100.36	99.74

Keratophyr, Marblehead Neck. Described by Sears, in Bull. Museum Compar. Zoölogy, vol. 16, No. 9, p. 170. Contains crystals of feldspar, with a decomposed base, irregular patches of quartz, some scales of biotite and grains of magnetite, and also some limonite and earthy matter. The feldspar is anorthoclase. Analyses by T. M.

A. The rock.
B. The separated feldspar.

	A.	B.
SiO_2	70.23	65.66
Al_2O_3	15.00	20.05
Fe_2O_3	1.99	trace
FeO	undet.	trace
MgO	.38	.18
CaO	.33	.67
Na_2O	4.98	6.56
K_2O	4.99	6.98
H_2O at 110°	.91	.04
H_2O at redness	1.28	.37
TiO_2?	.03	undet.
P_2O_5	.06	undet.
MnO	.24	.13
	100.42	100.64

Feldspars from schists of Berkshire County. Described by Wol Mon. XXIII, pp. 60 and 187. All albite. Analyses by R. B. Rig record Nos. 507 and 567.

A. From feldspathic schist, central shaft of the Hoosac tunnel. R. C. 129.

B, C. From the porphyritic mica-schist of Greylock Mountain.

	A.	B.	C.
SiO_2	69.69	68.08	67.83
Al_2O_3, Fe_2O_3	18.60	20.11	19.92
MgO	.20	(?)	(?)
CaO	trace	trace	trace
Na_2O	10.28	11.00	11.65
K_2O	.40	.36	.25
Ignition	.42	.31	.12
MnO	....	trace	trace
	99.59	99.86	99.77

Fe_2O_3 less than 0.5 in any case.

CONNECTICUT.

A. Olivine-basalt, main flow, Pine Hill, South Britain. Contains plagioclase, pink augite, olivine, and magnetite. The rock is quite fresh.

B. Olivine-basalt, anterior flow, South Britain. Contains plagioclase, uralitized augite, olivine, and magnetite. Rock much altered and containing numerous amygdules of calcite and prehnite, stained by iron.

Rocks A and B studied by W. H. Hobbs, who furnishes the petrographic data. Hitherto unpublished. Analyses by W. F. Hillebrand, record No. 1842.

C. Basic pitchstone (tachylyte), from the so-called "ash-bed" northeast of Meriden. Described by Emerson in Bull. Geol. Soc. Amer., vol. 8, p. 77. Analysis by H. N. Stokes, record No. 1641.

	A.	B.	C.
SiO_2	52.40	47.52	46.86
Al_2O_3	13.55	13.91	13.96
Fe_2O_3	2.73	7.06	5.23
FeO	9.79	3.76	4.67
MgO	5.53	6.84	7.69
CaO	10.01	5.71	9.42
Na_2O	2.32	3.06	1.85
K_2O	.40	.77	2.02
H_2O at 105°	.62	1.75	1.29
H_2O above 105°	1.05	4.55	3.43
TiO_2	1.08	1.19	1.13
P_2O_5	.12	.15	.15
NiO	trace	trace	
MnO	.28	.18	trace
SrO	none	none	trace
BaO	trace?	trace	.03
Li_2O	none	trace	trace
CO_2		3.68	2.19
F			trace
FeS_2 or Fe_7S_8 [a]	.13		
	99.99	100.13	99.92

[a] Calculated as pyrite

NEW YORK.

I. ROCKS OF THE ADIRONDACK REGION.

Collected by J. F. Kemp, who furnishes the petrographic data. A and G are described by Kemp in 19th Ann., Part III, p. 383. The other descriptions are hitherto unpublished. Analyses A and B by George Steiger, record No. 1715; C to G by W. F. Hillebrand, record No. 1717.

A. Wall rock of iron mine near Lincoln Pond, Elizabethtown. Varies from norite to gabbro. Chief minerals, green augite, hypersthene, brown hornblende, plagioclase, and magnetite. Microperthitic feldspar less common. Garnet varies from absence to abundance.

B. Coarse gabbro, top of Whiteface Mountain. A pyroxenic phase of the anorthosite. Contains much labradorite, abundant light-green augite, brown hornblende, shreds of more or less bleached brown biotite, and magnetite.

	A.	B.
SiO_2	44.77	53.18
Al_2O_3	12.46	23.25
Fe_2O_3	4.63	1.53
FeO	12.99	1.82
MgO	5.34	2.60
CaO	10.20	11.18
Na_2O	2.47	3.97
K_2O	.95	.86
H_2O at 100°	.12	.15
H_2O above 100°	.48	.98
TiO_2	5.26	.45
P_2O_5	.28	.09
NiO, CoO	trace?	(?)
MnO	.17	.11
BaO	trace?	trace?
CO_2	.37	.34
S	[a].26	trace
	100.75	100.51

[a] Mainly present as pyrrhotite.

C. Pyroxenic anorthosite, Elizabethtown. Contains largely labradorite, subordinate light-green augite, less brown hornblende, and a little magnetite.

D. Norite, with close affinity to gabbro. Intrusion in C. Contains labradorite, hypersthene, garnets, green augite, brown hornblende, a little brown biotite, magnetite, and apatite.

E. Diabasic norite or gabbro, Elizabethtown. Contains the same minerals as D.

F. Gneissoid derivative, by pressure, of E. The same minerals, but with hornblende more abundant.

G. Gabbro, wall rock of Split Rock mine. Contains augite, hypersthene, brown hornblende, garnet, plagioclase, magnetite, and possibly spinel.

	C.	D.	E.	F.	G.
SiO_2	56.94	47.16	44.97	46.74	47.88
Al_2O_3	20.82	14.45	15.38	16.63	18.90
Fe_2O_3	.83	1.61	2.29	2.17	1.39
FeO	3.02	13.81	12.39	10.60	10.45
MgO	2.36	5.24	10.89	6.11	7.10
CaO	9.41	8.13	7.50	8.66	8.36
Na_2O	3.36	3.09	3.02	3.81	2.75
K_2O	1.58	1.20	.56	.86	.81
H_2O at 110°	.21	.12	.10	.12	.18
H_2O above 110°	.59	.48	.65	.73	.43
TiO_2	.44	3.37	1.18	2.54	1.20
P_2O_5	.07	.57	.14	.33	.20
V_2O_3	(?)	(?)	.02	(?)	(?)
NiO, CoO	trace	.02	.02	.03	.02
MnO	.11	.24	.22	.26	.16
BaO	.05	trace	trace	trace	trace
CO_2	.45	.35	.23	.07	.12
S	trace	.14	.06	.11	.07
	100.24	99.98	99.64	99.77	100.02

ZrO_2, Cl, and F not looked for. Cr_2O_3, Li_2O, and SrO present in traces. S is in part, at least, present as pyrrhotite.

2. PERIDOTITE FROM DEWITT, NEAR SYRACUSE.

A rock described by Darton and Kemp, Amer. Journ. Sci., 3d series, vol. 49, p. 456. Contains olivine, partly serpentinized, biotite, and augite, with magnetite, apatite, and perofskite. Possibly a little chromite also. Classed by Kemp as limburgite.

Analysis by H. N. Stokes, record No. 1491. The FeO represents the total iron, because the sulphides present, possibly as pyrrhotite, prevent the separate estimation of the two iron oxides.

SiO_2	36.80	NiO	.09
Al_2O_3	4.16	MnO	.13
FeO	8.33	BaO	.12
MgO	25.98	SrO	trace
CaO	8.63	CO_2	2.95
Na_2O	.17	SO_3	.06
K_2O	2.48	S	.95
H_2O below 100°	.51		100.22
H_2O above 100°	6.93		
TiO_2	1.26	O=S	.47
P_2O_5	.47		99.75
Cr_2O_3	.20		

NEW JERSEY.

Rocks A, B, and C, described by J. P. Iddings in Bull. 150, pp. 2
9, 236. Analyses by Eakins, record No. 1299.

A. Basalt, Watchung Mountain, Orange. Contains pyroxene, most
alacolite, plagioclase, magnetite, and glass, with variable amounts
rpentine or chlorite. The feldspar is partly altered into a miner
iich is probably prehnite. P. R. C. 102.

B. Elæolite-syenite, Beemersville. Contains nephelite, orthoclase,
girite, and biotite, with melanite, sphene, apatite, zircon, and magne-
e in smaller amounts. Sodalite is probably present also. P. R. C. 78.

C. Minette, Franklin Furnace. Contains alkali-feldspar, biotite,
onoclinic pyroxene, magnetite, epidote, calcite, chlorite, apatite,
hene, pyrite, and a little secondary quartz. P. R. C. 91.

D. Nepheline-syenite, Brookville. Collected by N. H. Darton and
cribed by F. L. Ransome in Amer. Journ. Sci., 4th series, vol. 8,
417. Contains alkali-feldspars, nepheline largely altered to secondary
inerals, brown amphibole, biotite, cancrinite, plagioclase, muscovite,
girine-augite, apatite, titanite, fluorite, and a few specks of mag-
tite. Also secondary analcite, sericite, and natrolite (?). Analysis
Steiger, record No. 1807.

	A.	B.	C.	D.
SiO_2	51.36	53.56	40.71	54.68
Al_2O_3	16.25	24.43	19.46	21.63
Fe_2O_3	2.14	2.19	7.46	2.22
FeO	8.24	1.22	6.83	2.00
MgO	7.97	.31	6.21	1.25
CaO	10.27	1.24	11.83	2.86
Na_2O	1.54	6.48	1.80	7.03
$_2O$	1.06	9.50	3.26	4.58
$_2O$ at 100°	1.33	.93	1.53	.27
$_2O$ above 100°				1.88
O_2				.79
O_5				.28
O	.09	.10	.18	trace
	.03			
				.05
				.22
				.07
			.74	none
	100.28	99.96	100.01	99.81
=F				.09
				99.72

PENNSYLVANIA.

A. Aporhyolite, Monterey, Franklin County. Described by Florence Bascom in Bull. 150, p. 343. Contains alkali feldspars, quartz, sericite, epidote, titaniferous magnetite, leucoxene, and rarely sphene. Analysis by H. N. Stokes, record No. 1479. P. R. C. 136.

B. Quartz-porphyry, same locality. Analyzed for G. H. Williams, but never described. Analysis by L. G. Eakins, record No. 1350

	A.	B.
SiO_2	76.34	73.85
Al_2O_3	11.60	13.15
Fe_2O_3	2.41	3.27
FeO	.30	.36
MgO	.06	.32
CaO	.55	.82
Na_2O	5.50	2.29
K_2O	2.75	5.42
H_2O at 100°	.10	.71
H_2O above 100°	.39	
TiO_2	.26	....
P_2O_5	trace	.06
MnO	trace	.09
BaO	.09	....
CO_2	trace	....
	100.35	100.34

DELAWARE.

Feldspars from gabbros. Separated by Diller, described by Chester in Bull. 59. Analyses by R. B. Riggs, record Nos. 459, 460, 461.

A. Sp. gr. 2.592 to 2.877, from a typical gabbro, Brandywine Creek, Wilmington.

B. Sp. gr. 2.592 to 2.780, from a typical hypersthene-gabbro, Fifth and Van Buren streets, Wilmington.

C. Sp. gr. 2.592 to 2.749, from "Iron Hill hyperite changing to diorite," near Whitaker's ore pit.

	A.	B.	C.
SiO_2	70.37	51.44	44.09
Al_2O_3	18.36	30.05	35.41
Fe_2O_3	.58	.96	.51
MgO	.04	trace	none
CaO	5.08	13.19	18.47
Na_2O	4.32	4.07	.99
K_2O	.63	.21	.19
MnO	trace	....	trace
Ign	.45	.35	.35
	99.83	100.27	100.01

Samples dried at 105°. FeO not determined separately.

MARYLAND, INCLUDING THE DISTRICT OF COLUMBIA.

1. PERIDOTITE AND PYROXENITE.

Rocks A to I, inclusive, described by G. H. Williams in Amer. Geologist, vol. 6, p. 35.

A. Porphyritic lherzolite, Johnny Cake Road, Baltimore County. Contains olivine, bronzite, and diallage, the olivine partly serpentinized. Analysis by T. M. Chatard, record No. 1094.

B. Pyroxenite, Johnny Cake Road. Consists entirely of hypersthene and diallage. P. R. C. 110.

C, D. Alterations of B. B, C, and D dried at 104°.

E. Smaragdite rock, altered pyroxenite, Dogwood Road, Baltimore County.

Analyses B, C, D, and E by J. E. Whitfield, record Nos. 975, 976. C, D, and E are from the laboratory record, and do not appear in the published paper.

	A.	B.	C.	D.	E.
SiO_2	43.87	50.80	50.10	51.94	53.22
Al_2O_3	1.64	3.40	2.00	2.53	3.14
Fe_2O_3	8.94	1.39	2.38	2.88	....
FeO	2.60	8.11	8.68	9.38	7.95
MgO	27.32	22.77	26.85	25.97	20.09
CaO	6.29	12.31	5.06	3.60	14.44
Na_2O	.50	trace	none	none	trace
K_2O					
H_2O at 110°	1.08	.52	4.16	2.82	.98
H_2O at red heat	7.64				
TiO_2	.12	none	none	none	none
P_2O_5	trace	trace	none	none	....
Cr_2O_3	.44	.32	.36	.60	.23
NiO	trace	....	....	....	....
MnO	.19	.17	.29	trace	.11
SO_3	....	trace	trace	.19	trace
Cl	....	.24	.26	.16	.26
	100.63	100.03	100.14	100.07	100.42

F, G. Two samples of websterite, Hebbville, 6 miles west of Bal re.

H. Bronzite from G.

I. Diopside from G.

The rock consists entirely of bronzite and diopside. Analyses b M. Chatard, record Nos. 1094, 1123.

J. Websterite, Oakwood, Cecil County. Composed of hypersthene d diallage. Analysis by W. F. Hillebrand, record No. 1755. scribed by A. G. Leonard, but hitherto unpublished.

K. Cortlandtite, Ilchester, Howard County. Analysis by W. F. llebrand, record No. 1422. Published by Williams in Fifteenth n., page 674. The rock consists of olivine, pyroxene, and large nblende crystals, the latter considerably altered to talc.

	F.	G.	H.	I.	J.	K.
SiO_2	53.98	52.55	54.53	51.80	53.21	39.20
Al_2O_3	1.32	2.71	1.93	2.21	1.94	4.60
Fe_2O_3	1.41	1.27	1.70	1.29	1.44	3.45
FeO	3.90	4.90	8.92	3.50	7.92	6.15
MgO	22.59	20.39	29.51	17.76	20.78	31.65
CaO	15.47	16.52	2.25	20.99	13.12	3.23
Na_2O	undet.	.27		undet.	.11	.42
K_2O	undet.		....	undet.	.07	.14
H_2O at 100°	.09	1.09	1.14	.65	.14	.50
H_2O above 100°	.83				.87	9.38
TiO_2	.15	.14	undet.	.13	.26	.52
$_2O_5$	trace	trace	trace	trace	trace	trace
rO_2	....	....	....	....	trace	....
$_2O_3$	....	....	....	....	.03	....
$_2O_3$	.53	.44	.30	.51	.20	.41
O	trace	....	....	....	.03	.30
O	....	....	....	....		....
O	.21	.24	.28	trace	.22	.20
	....	....	....	....	none	....
	....	....	....	....	none	....
	....	....	....	....	trace	trace
	....	....	....	....	.03	....
	....	....	....	....	.10	....
	100.48	100.52	100.56	98.84	100.47	100.15

2. GABBRO AND DIORITE.

Rocks A to E, inclusive, described by G. H. Williams, but not in detail, in 15th Ann., pp. 673, 674. Some of the rocks, with other analyses, are discussed by him in Bull. 28. Analyses by W. F. Hillebrand, record No. 1422.

A. Olivine-gabbro, Orange Grove, Baltimore County. Contains plagioclase, diallage, hypersthene, fresh olivine, magnetite, and apatite, and sometimes hornblende.

B. Hypersthene-gabbro, Wetheredville, Baltimore County. Rich in hypersthene and diallage, with plagioclase, magnetite, and apatite.

C. Gabbro-diorite, Ilchester, Howard County. A coarse anorthite-hornblende rock, probably an altered gabbro.

D. Biotite-diorite, Triadelphia, Montgomery County.

E. Biotite-diorite, Georgetown, D. C.

To these may be added an apparently unpublished analysis made for Williams by L. G. Eakins, record No. 1350, as follows:

F. Hornblende-diorite, Rock Creek tunnel shaft, Washington, D. C. Relations to E not stated.

	A.	B.	C.	D.	E.	F.
SiO$_2$	48.91	44.76	43.42	55.97	56.41	56.18
Al$_2$O$_3$	8.81	18.82	22.37	15.60	15.19	14.76
Fe$_2$O$_3$	1.04	2.19	.81	1.21	1.60	2.12
FeO	9.52	4.73	9.25	6.28	6.24	6.98
MgO	15.19	11.32	5.75	6.83	7.18	8.11
CaO	14.69	14.58	13.34	7.31	6.77	7.97
Na$_2$O	.64	.89	1.24	2.23	2.21	1.62
K$_2$O	.10	.11	1.13	1.25	1.34	.80
H$_2$O at 100°	.07	.17	.09	.18	.08	1.37
H$_2$O above 100°	.52	2.36	1.54	1.85	2.00	
TiO$_2$	.37	.13	1.25	1.11	.69	....
P$_2$O$_5$	trace	none	.10	.16	.05	.08
SnO$_2$, ZrO$_2$?	....	....	....	....	.14	....
Cr$_2$O$_3$	.15	.08	trace	.04	.05	....
MnO	.16	.15	.06	.08	.11	.17
Li$_2$O	trace	trace	trace	trace	trace	....
	100.17	100.29	100.35	100.10	100.06	100.16

The following rocks, from Cecil County, have been studied by A. G. Leonard. Descriptions as yet unpublished.

G. Quartz-biotite-hornblende-diorite, near the foundry on Stone Run. Granitic in appearance.

H. Quartz-biotite-hornblende-diorite, near Porter's bridge on Octoraro Creek.

I. A true diorite with very little quartz, Stone Run, one-half mile northwest of the mill near Rising Sun.

J. Norite, three-fourths of a mile northwest of McKinsey's mill.

Analyses by Hillebrand, record No. 1755.

	G.	H.	I.	J.
SiO_2	58.57	55.16	44.04	48.02
Al_2O_3	16.10	17.51	20.01	20.01
Fe_2O_3	2.89	2.62	4.22	1.13
FeO	6.12	5.83	8.61	7.29
MgO	2.33	4.35	5.01	10.05
CaO	7.39	8.50	11.68	11.42
Na_2O	2.11	1.83	1.24	.51
K_2O	1.01	1.08	.15	.05
H_2O at 105°	.21	.18	.11	.10
H_2O above 105°	1.27	2.01	1.90	.57
TiO_2	1.41	.64	2.24	.23
P_2O_5	.37	.21	.52	trace
ZrO_2	.09	.02	.10	none
V_2O_3	.02	.04	.05	.02
Cr_2O_3	none	trace	none	.03
NiO, CoO	none	.01	.01	.01
MnO	.18	.15	.28	.18
SrO	trace	trace	none	none
BaO	trace	trace	none	none
Li_2O	trace	trace	trace	trace
FeS_2	trace	.03	.25	.11
CO_2	none	none	none	.25
	100.07	100.17	100.42	99.98

3. GRANITE AND GNEISS.

For descriptions see Williams, 15th Ann., p. 657, and Keyes, *ibid.*, p. 685. The Rowlandsville granite is described by Grimsley in Journ. Cincinnati Soc. Nat. Hist., vol. 17, p. 78.

A. White granite, Brookville, Montgomery County. (Williams.)

B. Binary granite, Guilford, Howard County. Contains quartz, orthoclase, a little plagioclase, muscovite, and biotite, with occasional zircon and apatite. (Keyes.)

C. Biotite-granite, Woodstock. Light colored, fine grained. Quartz, feldspar, and biotite, with accessory allanite and epidote. (Keyes.)

D. Biotite-granite, Rowlandsville, Cecil County. Dark colored. Contains plagioclase, orthoclase, quartz, epidote, biotite, sphene, magnetite, and apatite, with a little secondary muscovite. The percentages of the several minerals are computed by Grimsley from the analysis.

Analyses by W. F. Hillebrand, record Nos. 1220, 1422, 1455. In B and C manganese was present, barium and strontium were not tested for, and the alumina contains possible titanium and phosphoric acid.

	A.	B.	C.	D.
SiO_2	74.87	72.57	71.79	66.68
Al_2O_3	14.27	15.11	15.00	14.93
Fe_2O_3	trace	.59	.77	1.58
FeO	.51	1.02	1.12	3.32
MgO	.16	.30	.51	2.19
CaO	.48	1.65	2.50	4.89
Na_2O	3.06	3.92	3.09	2.65
K_2O	5.36	4.33	4.75	2.05
H_2O at 100°	.26	.47	.64	.16
H_2O above 100°	.66			1.09
TiO_2	.05	undet.	undet.	.50
P_2O_5	.21	undet.	undet.	.10
MnO	trace	undet.	undet.	.10
SrO	....	undet.	undet.	trace
BaO	....	undet.	undet.	.08
Li_2O	trace	trace	trace	trace
	99.89	99.96	100.17	100.32

E. Biotite-granite, Dorseys Run, Howard County. Typical, dark colored. Quartz, feldspar, and biotite, with accessory allanite and epidote. (Keyes.)

F. Same locality, light-colored dikes.

G. Inclusions in E. Derived from gneiss.

H. The typical gneiss of the Dorseys Run area. Perhaps of sedimentary origin.

Descriptions by Keyes. Analyses by Hillebrand. The remarks appertaining to B and C apply here also. Record No. 1220.

	E.	F.	G.	H.
SiO_2	62.91	70.45	57.33	48.92
Al_2O_3	19.13	15.98	15.31	16.57
Fe_2O_3	.98	.75	3.39	4.21
FeO	3.20	1.84	8.19	9.18
MgO	1.69	.77	4.36	5.98
CaO	4.28	2.60	3.95	9.69
Na_2O	3.94	3.83	1.22	2.47
K_2O	3.38	3.59	4.57	1.56
H_2O	.63	.45	1.80	1.68
Li_2O	trace	trace	trace	trace
	100.14	100.26	100.12	100.26

I. Biotite-granite, Sykesville. Contains quartz, feldspar, and biotite, with accessory magnetite, zircon, and apatite.

J. Inclusion in I, derived from limestone. Yellowish central portion. Consists of epidote and quartz, with a little chlorite.

K. Same inclusion, fine-grained dark outer zone. Quartz, garnet, and epidote, with a little magnetite. Feldspar and muscovite in some portions. Descriptions by Keyes. Analyses by Hillebrand, record No. 1220, with the same limitations as in the Guilford, Woodstock, and Dorseys Run granites.

	I.	J.	K.
SiO_2	71.45	67.02	47.35
Al_2O_3	14.36	13.77	29.76
Fe_2O_3	2.07	4.64	2.94
FeO	2.78	1.02	3.15
MgO	1.17	.65	1.60
CaO	1.58	11.09	2.20
Na_2O	1.95	.66	2.84
K_2O	3.28	.09	6.83
H_2O	1.30	1.16	3.15
Li_2O	trace	trace	trace
	99.94	100.10	99.82

L. Typical gneiss of Washington, D. C., from quarry of Potomac Stone Company, 1 mile below Chain Bridge. A basic granite.

M. Fine-grained, fissile, chloritic gneiss, from northwest of Cabin John Bridge. Also a basic granite.

N. Fine-grained, hard gneiss, from the second lock at the Great Falls of the Potomac. Probably of sedimentary origin.

Described by Williams. Analyses by Hillebrand, record No. 1459.

	L.	M.	N.
SiO_2	67.22	63.43	78.28
Al_2O_3	15.34	16.69	9.96
Fe_2O_3	2.78	3.36	1.85
FeO	3.41	3.87	1.78
MgO	1.65	2.33	.95
CaO	1.36	.80	1.68
Na_2O	2.00	2.38	2.73
K_2O	3.26	3.22	1.35
H_2O at 110°	.29	.23	.12
H_2O above 110°	1.68	2.67	.83
TiO_2	.84	.91	.70
P_2O_5	.14	.11	.11
MnO	.13	.09	.08
SrO	trace	trace	trace
BaO	.04	.03	.02
Li_2O	trace	trace	trace
	100.14	100.12	100.44

To these may be added three analyses of feldspars from the pegmatite of Jones Falls, Baltimore. Described by S. L. Powell in Johns Hopkins Univ. Circular, vol. 12, p. 49. Analyses by W. F. Hillebrand, record No. 1421.

O. Flesh-colored microcline.

P. Green microcline.

Q. Albite-oligoclase, near Ab_4An.

	O.	P.	Q.
SiO_2	65.06	68.48	63.72
Al_2O_3	18.41	16.11	22.26
Fe_2O_3	trace	.20	trace
FeO		.17	
MgO	.04	.03	.06
CaO	.26	.23	3.58
Na_2O	1.60	1.27	8.98
K_2O	14.30	12.99	.76
H_2O at 100°	.04	.06	.09
H_2O above 100°	.26	.26	.43
SrO	trace	trace	trace
BaO	.13	.05	....
	100.10	99.85	99.88

P contained a little unseparated quartz. All three contained traces of lithia. In O and Q the traces of iron were weighed with the alumina.

4. MISCELLANEOUS ROCKS.

A. Typical diabase, Rocky Ridge. Analyzed for J. S. Diller, but not described. Analysis by E. A. Schneider, record No. 1370.

B. Ottrelite-phyllite rock, Liberty, Frederick County. Analyzed for S. H. Williams, but not described.

C. Ottrelite separated from B. Analyses B and C by L. G. Eakins, record No. 1349.

D. Quartz-schist, Shoemaker quarry, near Stevenson Station, Green Spring Valley. Described by Bayley in Bull. 150, p. 302. Contains quartz, muscovite, occasional tourmalines, microcline, zircon, and iron stains. Analysis by Schneider, No. 1370. P. R. C. 119.

E. Mica separated from D. Analysis by Schneider, No. 1377.

F. Sericite-schist, Ladiesburg. Described by Bayley in Bull. 150, p. 317. Contains quartz, sericite, chlorite, a mineral thought to be kaolin, zircon, iron oxide, and rutile. Analysis by George Steiger, record No. 1600. P. R. C. 126.

G. Another sample of F. Analysis by Schneider, No. 1370.

	A.	B.	C.	D.	E.	F.	G.
SiO_2	51.68	34.92	23.40	91.65	44.93	57.24	58.11
Al_2O_3	15.87	32.31	39.31	1.59	29.81	23.48	21.84
Fe_2O_3	1.46	10.21	5.14	3.57	6.10	3.19	2.62
FeO	8.43	8.46	21.94	.21		4.87	5.63
MgO	7.84	1.13	2.18	.17	1.16	.93	1.85
CaO	11.08	.36	trace	none		.09	none
Na_2O	1.86	2.12	.20	.07	.50	1.18	.97
K_2O	.34	1.87	.20	1.93	10.28	3.55	3.66
H_2O at 100°	.16	5.29	6.81		1.38	.33	.35
H_2O above 100°	.15			.60	4.88	4.65	4.05
TiO_2	.72	3.37	1.19	.13	1.05	.08	.81
P_2O_5	.12	.23	trace	none		.09	.21
MnO	.15	trace	trace	trace	trace	none	.19
Li_2O					trace		
F					.22		
	99.86	100.27	100.37	99.92	100.31	99.68	100.29

VIRGINIA.

A. Andesite, 3½ miles east of Front Royal. Described by Keith in 14th Ann., p. 305. Intermediate between diabase and quartz-porphyry. Contains plagioclase, quartz, magnetite, ilmenite, and a little epidote. Analysis by George Steiger, record No. 1450.

B. Porphyritic felsite or felsophyre, forks of Straight Creek, 3 miles ENE. of Monterey. Described by Darton and Keith in Am. Journ. Sci., 4th series, vol. 6, p. 305. Contains phenocrysts of biotite, orthoclase, and plagioclase, the mica and feldspar being about equal in amount. In the groundmass are feldspar, quartz, magnetite, or ilmenite, and a little secondary chlorite with less muscovite. No glass. Analysis by Hillebrand, record No. 1665.

	A.	B.
SiO_2	51.08	69.56
Al_2O_3	11.37	15.52
Fe_2O_3	11.17	1.67
FeO	5.64	1.19
MgO	3.96	.41
CaO	5.20	1.20
Na_2O	5.54	4.46
K_2O	1.50	4.68
H_2O at 110°	1.31	.34
H_2O above 110°	.19	.67
TiO_2	2.67	.31
P_2O_5	.39	.08
MnO	.22	.07
SrO	....	trace
BaO	....	.10
Li_2O	....	trace
CO_2	....	none
Cl, F	....	(?)
S	....	trace
	100.24	100.26

NORTH CAROLINA.

Rocks A to F collected by Arthur Keith, who furnishes the petrographic data. Analyses B, C, D, and E by W. F. Hillebrand, record No. 1707. Analyses A and F by H. N. Stokes, record No. 1710.

A. Porphyritic rhyolite, 2 miles west of Barmers Elk, Watauga County. Contains orthoclase and plagioclase, with less quartz, epidote, chlorite, and pyrite.

B. Quartz-porphyry, 2½ miles northwest of Blowing Rock, Watauga County. Contains quartz and orthoclase, with subordinate sericite, chlorite, and biotite.

C. Diorite, east end of Hump Mountain, Mitchell County. Contains plagioclase, orthoclase, and hornblende, with less quartz, biotite, magnetite, and garnet.

D. Garnetiferous diabase, 1¾ miles southeast of Cranberry. Contains plagioclase and hornblende, with less garnet, biotite, and magnetite.

	A.	B.	C.	D.
SiO_2	62.35	79.75	46.91	52.11
Al_2O_3	13.24	10.47	15.85	13.70
Fe_2O_3	3.52	.64	2.86	1.22
FeO	6.33	.92	9.95	9.86
MgO	.85	.13	7.01	8.08
CaO	3.34	.15	9.62	12.16
Na_2O	2.79	1.36	2.65	1.31
K_2O	3.95	6.01	.69	.16
H_2O at 110°	.11	.08	.24	.06
H_2O above 110°	1.21	.60	1.62	.53
TiO_2	1.18	.15	2.03	.32
P_2O_5	.57	trace	.26	.05
ZrO_2	....	.05	none	none
Cr_2O_3	none	....	.01	....
V_2O_3	....	....	.03	....
CoO, NiO	none	none	.03	.03
MnO	.08	trace	.22	.20
SrO	trace	trace	trace?	none
BaO	.16	.06	trace?	none
Li_2O	trace	trace	trace	trace
S	....	none	none	trace
	99.68	100.37	99.98	99.79

E. Epidote-chlorite-schist, ¼ mile northeast of Montezuma, Mitchell County. Contains epidote and feldspar, with less chlorite, hornblende, and magnetite.

F. Metamorphosed amygdaloid, 3 miles southeast of Boone, Watauga County. Contains orthoclase and plagioclase, with less sericite, chlorite, and magnetite.

G. Pyroxenite, var. websterite, from Webster. Described by Williams, Amer. Geologist, vol. 6, p. 35. Consists of diopside and bronzite. Analysis by E. A. Schneider, record No. 1096. Material dried at 105°. P. R. C. 388.

H. Spherulitic rhyolite, Sam Christian gold mine, Montgomery County. Described by Diller, Amer. Journ. Sci., 4th ser., vol. 7, p. 337. The rock of the supposed fossil, palæotrochis. Contains feldspar and quartz, with a little biotite and sericite. Analysis by Hillebrand, record No. 1796.

	E.	F.	G.	H.
SiO_2	47.85	43.62	55.14	79.57
Al_2O_3	16.51	17.30	.66	11.41
Fe_2O_3	4.16	14.13	3.48	.20
FeO	7.43	6.83	4.73	.70
MgO	6.24	2.34	26.66	a little
CaO	7.00	1.63	8.39	.21
Na_2O	3.20	3.45	.30	3.46
K_2O	.82	3.03		3.52
H_2O at 110°	.21	.30	.38	.18
H_2O above 110°	4.00	2.93		.61
TiO_2	2.28	2.75	trace	.11
P_2O_5	.35	1.34	.23	trace
ZrO_2	.03			
Cr_2O_3	.01	none	.25	
V_2O_3	.05			
CoO, NiO	.03	none	.11	
MnO	.24	trace	.03	none
SrO	trace?	trace		
BaO	trace?	.09		.05
Li_2O	trace	trace		
	100.41	99.74	100.36	100.02

The following rocks from Corundum Hill were collected, analyzed, and described by T. M. Chatard, Bull. 42, p. 45.

I. Altered gneiss. Made up of micaceous scales, with grains of quartz and some earthy matter. Record No. 238.

J. Dunite. Olivine rock containing a little chromite. Record No. 256.

K, L. Yellow, clay-like alterations of dunite. Record Nos. 254, 255.

Other analyses of altered rocks are given in the paper, and also analyses of associated minerals.

	I.	J.	K.	L.
SiO_2	64.27	40.11	40.18	40.04
Al_2O_3	16.75	.88	1.35	3.17
Fe_2O_3	6.08	1.20	10.97	12.15
FeO	.89	6.09		
MgO	1.74	48.58	43.84	42.97
CaO	.25			
Na_2O	.89			
K_2O	3.09			
H_2O (Ign.)	4.97	2.74	2.01	2.14
TiO_2	1.32		none	none
P_2O_5	.05			
Cr_2O_3		.18	1.41	
MnO	.07			
Chromite		.56		.17
	100.37	100.34	99.76	100.64

GEORGIA.

Rocks collected by A. H. Brooks, who supplies tne petrographic data. Hitherto unpublished. Analyses by H. N. Stokes, record No. 1727.

A. Meta-quartz-diorite, 2 miles southwest of Sweden, Gordon County. Contains plagioclase, near labradorite, green hornblende, sometimes diallage, much vitreous quartz, and accessory magnetite, ilmenite, and orthoclase. Also secondary epidote, zoisite, uralite, chlorite, garnet, calcite, and leucoxene.

B. Augite-microcline-granite, 1 mile east of Rowland, Bartow County. Contains microcline, some plagioclase, abundant pyroxene partly altered into chiefly uralite and chlorite, some biotite with frequent inclusions of rutile, much blue vitreous quartz, apatite, zircon, and magnetite.

C. Quartz-gabbro, 2 miles southeast of Walleska, Cherokee County. Closely related to B. Contains essentially plagioclase, near labradorites, and augite. Accessory magnetite, ilmenite, apatite, and zoisite. Orthoclase is sparingly present. Quartz occurs in vitreous masses.

	A.	B.	C.
SiO_2	69.87	67.98	56.20
Al_2O_3	12.02	14.84	15.46
Fe_2O_3	1.42	1.00	1.54
FeO	3.49	3.15	9.76
MgO	2.30	.91	1.83
CaO	7.86	2.17	5.39
Na_2O	.66	2.66	2.78
K_2O	.11	4.76	2.56
H_2O at 110°	.18	.14	.16
H_2O above 110°	.89	.49	.59
TiO_2	.69	.84	2.25
P_2O_5	.17	.34	1.13
MnO	.16	trace	.13
BaO	none	.20	.17
SrO	none	trace	trace
Li_2O	trace	trace	none
CO_2	.43	none	none
S	none	.08	.07
SO_3	none	trace	trace
Cl	none	trace	trace
F	(?)	trace	trace
C (graphite)	....	.21	....
	100.25	99.77	100.02

KENTUCKY.

1. THE ELLIOTT COUNTY DIKE.

Described by Diller in Bull. 38. Also in Amer. Journ. Sci., 3d series, vol. 32, p. 125.

A peridotite, var. kimberlite, consisting largely of olivine, sometimes altered to serpentine. Pyrope, ilmenite, a few scales of biotite, a little enstatite, and a trace of apatite are present as primary minerals. Secondary minerals are serpentine, dolomite, magnetite, and octahedrite. P. R. C. 799.

A granitic rock occurs with the peridotite. It consists chiefly of feldspar, orthoclase, and plagioclase, with a considerable amount of quartz and ilmenite, and traces of hornblende, sphene, and apatite.

Analyses by T. M. Chatard, record Nos. 272, 273, 282, 305, 351, 352, 353, 354, and 358.

A. Granite.
B. Peridotite (kimberlite).
C. Olivine from peridotite.
D. Garnet from peridotite.
E. Ilmenite from peridotite.

	A.	B.	C.	D.	E.
SiO_2	60.56	29.81	40.05	41.32	.76
Al_2O_3	16.19	2.01	.39	21.21	2.84
Fe_2O_3	5.19	5.16	2.36	4.21	9.13
FeO	2.41	4.35	7.14	7.93	27.81
MgO	1.30	32.41	46.68	19.32	8.68
CaO	2.09	7.69	1.16	4.94	.23
Na_2O	4.78	.11	.08	.07	.19
K_2O	4.82	.20	.21	....	
H_2O, 110°	....	8.92	.14	.17	.20
H_2O, ign	.51		.66		
TiO_2	1.19	2.20	.07	.16	49.32
P_2O_5	.30	.35	.04	none	trace
Cr_2O_3	....	.43	.24	.91	.74
MnO	.36	.23	.20	.34	.20
NiO	....	.05	....	....	....
CoO	....	....	trace	....	....
CO_2	....	6.66	?	....	....
SO_3	....	.28	....	....	....
	99.70	100.86	99.42	100.58	100.10

The following analyses are of sedimentary rocks adjoining the dike:

F. Calcareous standstone.
G. Fine-grained fissile sandstone.
H. Indurated shale.
I. Fragment of shale included in the peridotite.

	F.	G.	H.	I.
SiO_2	60.78	60.25	41.32	35.53
Al_2O_3	10.54	20.18	20.71	18.23
Fe_2O_3	3.27	1.53	2.59	2.46
FeO	....	3.42	5.46	4.81
MgO	1.59	3.52	1.91	2.01
CaO	10.15	.51	9.91	21.17
Na_2O	1.41	.39	7.19	2.53
K_2O	2.36	3.17	.88	1.08
H_2O, 110°	.85	1.94	....	1.40
H_2O, ign	2.32	5.17	8.78	9.00
TiO_2	.03	.23	.48	.95
P_2O_5	.09	.10	.08	.08
Cr_2O_3	....	....	trace	....
MnO	.10	.10	.17	.13
CO_2	6.29	....	.55	.88
	99.78	100.51	100.03	100.26

H was dried five hours at 110°, previous to analysis.

2. THE CRITTENDEN COUNTY DIKE.

A mica-peridotite, described by Diller in Amer. Journ. Sci., 3d series, vol. 44, p. 286. Contains biotite, serpentine, and perofskite, with less apatite, muscovite, magnetite, calcite, chlorite, and some other secondary products. P. R. C. 800.

A. The rock described by Diller. Analysis by W. F. Hillebrand, record No 1241.

B. An unpublished analysis of probably the same rock, from a shaft 40 feet deep at Marion. Collected by J. R. Procter, analyzed by L. G. Eakins, record number 965.

	A.	B.
SiO_2	33.84	34.50
Al_2O_3	5.88	14.37
Fe_2O_3	7.04	2.85
FeO	5.16	4.46
MgO	22.96	21.81
CaO	9.46	11.43
Na_2O	.33	.51
K_2O	2.04	1.50
H_2O	7.50	7.14
TiO_2	3.78	....
P_2O_5	.89	.77
Cr_2O_3	.18	....
MnO	.16	....
NiO	.10	....
CoO	trace	....
BaO	.06	....
Cl	.05	....
CO_2	.43	.21
SO_3	....	.60
	99.86	100.15

TENNESSEE.

Gabbro, 2 miles south of Limestone Cove, Unicoi County. Collected by Arthur Keith, who furnishes the petrographic data. Analysis by W. F. Hillebrand, record No. 1707. Contains hypersthene, plagioclase, and magnetite.

SiO_2	48.11	ZrO_2	(?)
Al_2O_3	14.74	Cr_2O_3	.01
Fe_2O_3	2.54	V_2O_3	.03
FeO	11.85	NiO, CoO	.03
MgO	5.10	MnO	.19
CaO	6.72	SrO	.02
Na_2O	2.92	BaO	.04
K_2O	1.92	Li_2O	trace
H_2O at 110°	.27	FeS_2	[a] .13
H_2O above 110°	1.73		99.96
TiO_2	3.17		
P_2O_5	.44		

[a] Equivalent to 0.07 S. Assumed to be pyrite, no pyrrhotite being present.

MISSOURI.

Granite and porphyry, 6 miles east of Ironton. Described by Haworth in Mo. Geol. Survey, vol. 8, Annual Report, pp. 140, 180, and 213. Analyses by W. H. Melville, record No. 1206.

A, B. Granite. A, P. R. C. 1027; B, P. R. C. 1028.

C, D. Porphyry. C, P. R. C. 1029; D, P. R. C. 1030.

Rocks composed principally of orthoclase and quartz, with some microcline, plagioclase, and biotite, and minor accessory minerals.

	A.	B.	C.	D.
SiO_2	69.94	72.35	71.33	71.88
Al_2O_3	15.19	13.78	12.55	12.88
Fe_2O_3	1.88	1.87	3.75	3.05
FeO	.60	.36	.85	1.05
MgO	.92	.42	.58	.33
CaO	1.15	.87	.94	1.13
Na_2O	3.95	4.44	4.52	4.21
K_2O	4.29	4.49	4.20	4.46
H_2O at 100°	.14	.22	.12	.17
H_2O above 100°	.85	.54	.30	.26
TiO_2	.25	.44	.55	.22
P_2O_5	.13	.13	.16	.15
NiO	trace	.20	.15	.02
MnO	.03	.06	.04	trace
	99.32	99.87	100.04	99.81

ARKANSAS.

Ouachitite, dike near Maple Spring, 4 miles southwest of Hot Springs. Described by Kemp, in Ann. Rep. Geol. Survey Arkansas, 1890, vol. 2, p. 399. A dike rock of the monchiquite group. Contains abundant and conspicuous augite and biotite, magnetite, and minor accessory minerals in a groundmass considered by Kemp as glass. Calcite and other secondary products are also present. According to Pirsson, Journ. Geol., vol. 4, p. 679, the so-called "glass" in the monchiquites is really analcite. Analysis by L. G. Eakins, record No. 1023.

SiO_2	36.40	K_2O	3.01
Al_2O_3	12.94	H_2O	2.36
Fe_2O_3	8.27	TiO_2	.42
FeO	4.59	P_2O_5	1.04
MgO	11.44	CO_2	3.94
CaO	14.46		[illegible]
Na_2O	.97		

T

A. Quartz-pantellarite,
County. Description fu
clase, augite, and grain
a brown hornblende,
quartz. Ma
Analysis by

The following rocks from Uvalde County were collected by T. Wayland Vaughan. Petrographic data furnished by Whitman Cross. Analyses by W. F. Hillebrand, record No. 1681.

B. Plagioclase-basalt, Pinto Mountain, Brackett quadrangle. Contains olivine, augite, plagioclase (labradorite), biotite, a very little alkali feldspar (?), magnetite, and apatite. Sp. gr. 3.118, 20°. P. R. C. 1067.

C. Basanite, Mount Inge, Uvalde quadrangle. Contains sanidine, nephelite, hornblende, augite, ægirine augite, olivine, magnetite, apatite, and a trace of pyrite. Sp. gr. 2.770, 20°. P. R. C. 1069.

D. Rock of basaltic habit, allied to C, 1 mile northeast of Big Mountain, Uvalde quadrangle. Contains alkali feldspar, augite, magnetite, and variable amounts of olivine, nephelite, ægirite, biotite, and zeolitic minerals. Sp. gr. 2.742, 23°. P. R. C. 1068.

	A.	B.	C.	D.
SiO_2	68.71	45.11	48.13	48.23
Al_2O_3	13.45	a 12.44	18.44	17.43
Fe_2O_3	5.31	2.67	3.41	2.77
FeO	.75	9.36	4.30	5.92
MgO	.19	11.56	3.06	2.99
CaO	.96	10.61	5.89	6.38
Na_2O	4.63	3.05	8.00	6.87
K_2O	5.51	1.01	3.80	2.78
H_2O at 110°	.13	.16	.18	.54
H_2O above 110°	.36	.78	1.59	2.84
TiO_2	.21	2.34	1.74	2.00
P_2O_5	.04	.51	.49	.69
ZrO_2	....	(?)	.05	.04
Cr_2O_3	....	....	none	none
V_2O_3	....	.04	....	.04
NiO	....	.04	.02	trace
MnO	.14	.22	.19	.18
SrO	none	trace	.10	.08
BaO	none	trace	.10	.08
Li_2O	none	none	trace	trace
S	....	.01	.09	.08
SO_3	.05	....	....	....
Cl	....	.11	.29	.03
F	....	undet.	.06	undet.
	100.44	100.02	99.93	99.97
Less O	....	.02	.09	....
		100.00	99.84	

a Including Cr_2O_3.

E. Phonolite, hill between Black and Big mountains, Uvalde quadrangle. Contains sanidine, nephelite, and ægirite, and very little brown hornblende, augite, and magnetite. Sp. gr. 2.559, 19.5°. P. R. C. 1070.

F. The portion of E soluble in 1:40 dilute nitric acid.

G. Nepheline-basalt, Tom Munns Hill, Uvalde quadrangle. Contains olivine, augite, nephelite, magnetite, and apatite. Sp. gr. 3.148, 19°. P. R. C. 1065.

H. The portion of G soluble in 1:40 dilute nitric acid.

	E.	F.	G.	H.
SiO_2	54.42	26.90	40.32	12.27
Al_2O_3	20.76	14.34	[a]9.46	6.09
Fe_2O_3	2.64	....	4.75	....
FeO	1.33	.60	7.48	2.83
MgO	.22	(?)	18.12	6.48
CaO	1.34	.30	10.55	1.45
Na_2O	10.41	8.32	2.62	2.39
K_2O	4.89	1.22	1.10	.93
H_2O at 110°	.22	(?)	.57	(?)
H_2O above 110°	2.50	(?)	1.25	(?)
TiO_2	.40	....	2.66	....
P_2O_5	.11	.11	.68	.68
ZrO_2	.15	....	none	....
Cr_2O_3	none	....	....	....
NiO	none	....	.06	....
MnO	.15	....	.25	....
SrO	trace	....	.03	....
BaO	.04	....	.06	....
Li_2O	trace	....	trace	....
S	.01	....	.01	....
SO_3	....	....	.03	....
Cl	.23	....	.05	....
F	none	....	.04	....
	99.82	51.79	100.09	33.12
Less O	.05	....	.03	....
	99.77	....	100.06	....

[a] Including Cr_2O_3

I. Nepheline-basalt, Black Mountain, Uvalde quadrangle. Contains ivine, augite, nephelite, magnetite, and apatite. Sp. gr. 3.200, .5°. P. R. A. 1066.

J. The portion of I soluble in 1:40 dilute nitric acid.

K. Augite from I. Violet in color, very pure.

L. Nepheline-melilite-basalt, from about 3 miles southwest of valde. Contains nephelite, melilite, olivine, augite, magnetite, d apatite. Sp. gr. 3.150, 20.5°. P. R. C. 1064.

M. The portion of L soluble in 1:40 dilute nitric acid.

	I.	J.	K.	L.	M.
SiO_2	39.92	12.00	45.23	37.96	19.32
Al_2O_3	8.60	5.15	7.73	10.14	7.12
Fe_2O_3	4.40		2.95	3.69	
FeO	8.00	3.38	4.07	7.59	3.16
MgO	20.17	7.16	12.25	14.69	6.52
CaO	10.68	1.33	23.37	16.28	7.75
Na_2O	1.91	1.77	.47	2.18	2.11
K_2O	1.03	.77	.12	.69	.67
H_2O at 110°	.43	(?)	.37	.39	(?)
H_2O at above 110°	1.45	(?)		1.82	(?)
Ti_2O	2.70		4.28	2.93	trace
P_2O_5	.51	.51	none	1.13	1.13
ZrO_2	none			none	
Cr_2O_3	.14			.08	
V_2O_3	.04			.05	
NiO	.06		.05	.04	
MnO	.24		.07	.22	
SrO	.04		none	.05	
BaO	.06		none	.06	
Li_2O	trace		trace	trace	
SO_3				.03	
S	trace			.04	
Cl	trace			trace	
F	.07			.07	
	100.45	32.07	100.96	100.13	47.78
Less O	.03			.03	
	100.42			100.10	

LAKE SUPERIOR REGION.

1. MARQUETTE REGION, MICHIGAN.

Rocks mostly described by Van Hise and Bayley. When not otherwise specified the descriptions have been published in Mon. XXVIII, and partly in 15th Ann., p. 485.

A. Peridotite, near Opin Lake, E. ½ sec. 27, T. 48 N., R. 27 W. Contains diallage, olivine, magnetite, and plagioclase. The diallage is partly chloritized, and the olivine is partly serpentinized. Analysis by W. F. Hillebrand, record No. 1452. P. R. C. 996.

B. Altered greenstone, Marquette district. Analysis by George Steiger, record No. 1586, hitherto unpublished. P. R. C. 988.

C. Grünerite-magnetite-schist, sec. 11, T. 47 N., R. 27 W. Mainly impure grünerite, with magnetite and quartz. Analysis by W. H. Melville, record No. 1403. P. R. C. 984.

D. Like C, from sec. 18, T. 47 N., R. 28 W. Analysis by Melville, record No. 1403. P. R. C. 980.

E. Like C and D, from sec. 20, T. 46 N., R. 30 W. Analysis by H. N. Stokes, record No. 1546. C, D, and E are similar schists, and alike in mineralogical composition.

	A.	B.	C.	D.	E.
SiO_2	39.37	48.85	46.94	49.70	46.25
Al_2O_3	4.47	15.83	.66	1.35	.92
Fe_2O_3	4.96	2.50	4.51	3.10	30.62
FeO	9.13	10.79	33.72	37.19	16.92
MgO	26.53	5.82	6.64	5.72	2.13
CaO	3.70	6.20	3.22	.68	1.69
Na_2O	.50	2.79	.16	trace	none
K_2O	.26	1.31	....	....	none
H_2O at 110°	.87	.27	.67	1.40	....
H_2O above 110°	7.08	3.77			.42
TiO_2	.66	1.28	none	....	none
P_2O_5	.17	.22	.07	.12	.07
Cr_2O_3	.68	....	....	....	....
MnO	.12	.11	.31	.93	1.01
NiO	.21	....	....	....	none
CuO	....	....	....	....	trace
SrO	trace	.09	....	....	none
BaO	trace	none	....	....	none
CO_2	1.23	none	2.79	....	none
SO_3	....	.06	....	....	....
	99.94	99.89	99.69	100.19	100.03

F. Green schist, sec. 34, T. 48 N., R. 27 W., near center of section. ontains plagioclase, chlorite, and quartz. Analysis by George Steier, record No. 1447. P. R. C. 986.

G. Sericite-schist associated with the preceding. Mainly sericite nd quartz. Analysis by Steiger, No. 1447. P. R. C. 985.

H. Dark-gray, foliated schist, SE. corner of sec. 30, T. 47 N., R. 0 W. Contains quartz, plagioclase, orthoclase, and biotite. Analysis y Steiger, No. 1525. P. R. C. 991.

I. Schistose gneiss, NW. ¼ of sec. 35, T. 47 N., R. 26 W. Contains uartz, kaolin, sericite, plagioclase, chlorite, magnetite, and apatite. nalysis by Steiger, No. 1525.

J. Novaculite from Marquette. Described by Williams in Bull. 62. ontains quartz and sericite. Analysis by W. F. Hillebrand, record o. 759.

	F.	G.	H.	I.	J.
SiO_2	61.35	70.76	63.50	82.38	76.99
Al_2O_3	16.45	14.83	17.89	11.32	13.92
Fe_2O_3	.94	1.46	1.12	.97	.45
FeO	4.20	3.09	5.38	.26	.77
MgO	3.12	1.99	1.22	.17	1.12
CaO	3.46	.36	2.34	.22	.32
Na_2O	5.24	.47	2.55	.59	.56
K_2O	1.05	3.50	2.43	1.04	3.65
H_2O at 100°	.10	.09	.22	.18	2.35
H_2O above 100°	2.51	2.70	2.04	2.33	
TiO_2	.26	.33	.62	.14	....
P_2O_5	.18	.26	.19	.09	trace
MnO	....	....	trace	none	trace
Li_2O	....	....	....	....	trace
CO_2	1.98	....	....	....	....
	100.84	99.84	99.50	99.69	100.13

2. CRYSTAL FALLS DISTRICT, MICHIGAN.

Rocks described by J. Morgan Clements and H. L. Smyth, in Mo XXXVI. A, B, C, and D by Smyth, p. 274. Analyses by H. Stokes, record No. 1721.

A. Granite, sec. 2, T. 41 N., R. 30 W. Contains quartz, orthocla microcline, plagioclase, biotite, muscovite, magnetite, hematite, tita ite, and occasional apatite.

B. Gneiss, sec. 35, T. 42 N., R. 29 W. Same minerals as in A.

C. Mica-schist, sec. 35, T. 42 N., R. 29 W. Contains biotite, quar some microcline, and magnetite.

D. Amphibolite, sec. 32, T. 42 N., R. 28 W. Contains hornblend plagioclase, biotite, and quartz, with a little rutile and magnetite.

	A.	B.	C.	D.
SiO_2	76.10	74.37	64.71	50.36
Al_2O_3	12.95	13.34	16.43	13.26
Fe_2O_3	.65	.92	1.83	6.30
FeO	.09	.21	3.84	9.34
MgO	.14	.27	2.97	5.55
CaO	.12	.50	.08	7.85
Na_2O	2.36	2.50	.11	2.11
K_2O	6.50	6.70	5.63	1.14
H_2O at 110°	.17	.12	.31	.16
H_2O above 110°	.48	.44	2.79	1.55
TiO_2	.07	.07	.72	1.77
P_2O_5	.02	.01	.02	.20
MnO	trace	trace	trace	trace
	99.65	99.45	99.44	99.59

Ba, Sr, Cl, F, S, SO_3 not looked for.

The following rocks, with one exception, are described by Clements in his portion of Mon. XXXVI:

E. Mica-diorite, sec. 28, T. 42 N., R. 32 W., southeast of Crystal Falls. Contains plagioclase (andesine), orthoclase, quartz, biotite, hornblende, and titaniferous magnetite. Analysis by Stokes, record No. 1721.

F. Hornblende-gabbro, sec. 29, T. 42 N., R. 31 W., west bank Michigamme River, east of Crystal Falls. Contains labradorite, hornblende, and iron oxide, with subordinate pyroxene, biotite, and orthoclase. Analysis by George Steiger, record No. 1712.

G. Bronzite-norite, same locality as F. Contains bronzite, hornblende, and labradorite. Analysis by Steiger, record No. 1712.

H. Wehrlite, sec. 29, T. 42 N., R. 31 W., on Michigamme River, east of Crystal Falls. Contains hornblende, pyroxene, olivine, biotite, and iron oxide. Analysis by Stokes, record No. 1721.

I. Picrite-porphyry, sec. 27, T. 44 N., R. 32 W., northwest of Mansfield. Principal minerals serpentine, amphibole, chlorite, ilmenite, all but the last being secondary. Analysis by Stokes, record No. 1721.

	E.	F.	G.	H.	I.
SiO_2	58.51	49.80	48.23	44.99	37.36
Al_2O_3	16.32	19.96	18.26	5.91	4.76
Fe_2O_3	2.11	6.32	1.26	3.42	6.61
FeO	4.43	.49	6.10	8.30	6.12
MgO	3.73	7.05	10.84	21.02	31.11
CaO	3.92	11.33	9.39	9.79	1.19
Na_2O	3.11	2.22	1.34	.91	trace
K_2O	4.08	.61	.73	.74	trace
H_2O at 110°	.23	.13	.26	.63	.65
H_2O above 110°	2.00	1.71	2.00	3.19	10.37
TiO_2	.72	.79	1.00	.97	.79
P_2O_5	.30	.07	.07	.05	.06
Cr_2O_3	....	....	....	.25	.62
MnO	trace	....	....	trace	trace
NiO	....	....	....	....	.04
CO_2	none	.15	.43	trace?	none
	99.46	100.63	99.91	99.17	99.68

Ba, Sr, Cl, F, S, SO_3 not looked for.

J. Pre-Cambrian nonporphyritic metabasalt, from the Hemlock formation. Contains plagioclase, light-green hornblende, epidote-zoisite, chlorite, calcite, muscovite, apatite, sphene, quartz, pyrite, and magnetite.

K. Porphyritic metabasalt, Hemlock formation. Same minerals as in J, with feldspar phenocrysts.

L. Porphyritic metabasalt, like K.

M. Metadolerite, large dike in T. 43 N., R. 31 W., east of Mansfield. Hitherto unpublished. Petrographic data furnished by C. R. Van Hise. Contains uralite, labradorite, and ilmenite.

Analyses J, K, and L by H. N. Stokes, record No. 1617.

Analysis M by George Steiger, record No. 1814.

	J.	K.	L.	M.
SiO_2	46.47	47.20	52.59	44.29
Al_2O_3	16.28	15.36	15.89	17.46
Fe_2O_3	3.15	3.06	6.12	3.82
FeO	8.96	8.87	3.96	10.35
MgO	6.56	4.20	5.04	7.03
CaO	7.90	5.05	5.55	8.68
Na_2O	3.64	4.72	5.79	2.19
K_2O	.21	1.40	.67	.71
H_2O at 110°	.28	.16	.16	.21
H_2O above 110°	3.89	3.04	2.16	4.11
TiO_2	1.28	3.30	1.36	1.40
P_2O_5	.13	.36	.15	.20
V_2O_3	....	....	.04	....
Cr_2O_3	.01	none	trace	....
MnO	.09	.20	.25	trace
CuO	trace	trace	trace	....
SrO	none	trace	none	....
BaO	none	trace	trace	none
Li_2O	trace	trace	none	....
CO_2	1.26	3.34	none	....
S	none	trace	none	....
F	trace	trace	trace	....
	100.11	100.26	99.73	100.45

N. Adinole, sec. 8, T. 43 N., R. 31 W., near Mansfield. Contains tinolite, albite, quartz, some chlorite, and epidote. Analysis by eorge Steiger, record No. 1709.

O. Spilosite. Contains quartz, feldspar, chlorite, epidote, and a ttle biotite.

P. Spilosite. Contains quartz, feldspar, actinolite, and epidote. Analyses O and P by H. N. Stokes, record No. 1617. These three cks are contact derivatives of the Mansfield clay slate, q. v.

	N.	O.	P.
SiO_2	74.16	52.51	57.77
Al_2O_3	11.85	19.00	19.33
Fe_2O_3	.82	3.31	1.29
FeO	1.66	7.19	3.37
MgO	2.10	3.29	4.35
CaO	2.10	1.55	1.71
Na_2O	6.57	6.72	8.22
K_2O	.15	.70	.22
H_2O at 110°	.05	.34	.18
H_2O above 110°	.52	3.26	2.34
TiO_2	.37	1.70	.92
P_2O_5	.08	.15	.04
MnO	.06	trace	trace
SrO	none	trace	trace
BaO	none	trace	none
V_2O_3			.02
Li_2O		trace	none
CO_2	.09	none	none
C	.18		
F		trace	none
	100.76	99.72	99.76

3. MENOMINEE RIVER.

1ST. STURGEON FALLS GABBRO.

From Sturgeon Falls, Menominee River, sec. 27, T. 39 N., R. 29 W., Michigan. Described by Williams, Bull. 62, p. 67.

A. Saussurite-gabbro. Contains plagioclase, almost wholly altered to saussurite, diallage, hornblende, and ilmenite, with quartz, calcite, and chlorite as alteration products.

B. The same, altered and somewhat schistose. Feldspar much altered into calcite, with secondary quartz and sericite; pyroxene and hornblende changed to chlorite. Leucoxene common.

C. Light-gray, silvery schist, derived from gabbro. Contains chlorite, calcite, and a little quartz, with remnants of feldspar and some leucoxene. Analyses by R. B. Riggs, record Nos. 389, 390, 391. Material dried at 105°. TiO_2 undetermined.

	A.	B.	C.
SiO_2	51.46	38.05	45.70
Al_2O_3	14.35	24.73	16.53
Fe_2O_3	3.90	5.65	4.63
FeO	5.28	6.08	3.89
MgO	9.54	11.58	9.57
CaO	9.08	1.25	4.28
Na_2O	2.92	2.54	.55
K_2O	.24	1.94	3.82
H_2O	3.30	7.53	4.70
CO_2	.20	.93	5.95
	100.27	100.28	99.62

2D. LOWER QUINNESEC FALLS, MENOMINEE RIVER.

Described by Williams, Bull. 62, pp. 89, 91.

A. Gabbro-diorite, shore below falls, Wisconsin side. Contains aussurite, hornblende, and ilmenite. Some calcite in the saussurite. Hornblende partly altered to chlorite and ilmenite to leucoxene.

B. The same, schistose form. Contains less saussurite. Hornblende nd ilmenite completely altered into chlorite and leucoxene. Calcite resent, and also porphyritic feldspar.

C. Silvery schist, adjoining B, and derived from gabbro. Resembles B in general, without the feldspar crystals. Calcite and sericite are resent, and rutile in place of leucoxene.

D. Dark, massive greenstone. Contains hornblende, chlorite, epiote, quartz, leucoxene, with some ilmenite and traces of original eldspar.

E. Dark, schistose greenstone, forming a band in D. Chlorite ntirely replaces hornblende, and rutile replaces leucoxene. Some eldspar, quartz, and calcite.

Analyses by R. B. Riggs, record Nos. 384, 385, 386, 387, 388. Mateial dried at 105°.

	A.	B.	C.	D.	E.
SiO_2	47.96	49.19	46.21	43.80	44.49
Al_2O_3	16.85	18.71	18.38	16.08	16.37
Fe_2O_3	4.33	5.03	3.30	9.47	5.07
FeO	4.17	4.04	3.90	10.50	5.50
MgO	9.15	7.98	7.03	6.54	7.50
CaO	13.25	5.92	6.28	7.81	7.94
Na_2O	1.25	1.44	2.14	1.96	2.59
K_2O	.30	.77	.35	.34	.56
H_2O	2.89	5.05	3.82	3.99	4.99
CO_2	.08	1.82	8.32	.08	5.38
	100.23	99.95	99.73	100.57	100.39

3D. UPPER QUINNESEC FALLS, MENOMINEE RIVER.

Described by Williams, Bull. 62, pp. 104, 113, 114, 121.

A. Light greenstone. Contains hornblende, feldspar much altered to saussurite, ilmenite with leucoxene border, and some secondary quartz.

B. Mica-diorite-porphyry. Mainly andesitic feldspar and biotite, with apatite, zircon, sphene, and some calcite.

C. Biotite-gneiss, Michigan side. Contains biotite, soda-orthoclase, and quartz. Sphene common, zircon and apatite present.

D. Schistose quartz-porphyry. Contains quartz, feldspar, sericite, some chlorite, anatase, and tourmaline, with zircon and apatite sparingly.

A, B, and D are from the Wisconsin side of the river.

Analyses by R. B. Riggs, record Nos. 392, 393, 394, 395. Material dried at 105°.

	A.	B.	C.	D.
SiO_2	48.35	54.83	67.77	66.69
Al_2O_3	15.40	25.49	16.61	16.69
Fe_2O_3	4.04	1.61	2.06	2.06
FeO	4.63	1.65	1.96	.93
MgO	11.61	1.96	1.26	1.15
CaO	10.38	6.08	1.87	1.40
Na_2O	1.87	5.69	4.35	2.46
K_2O	.35	1.87	2.35	5.23
H_2O	3.60	1.18	1.69	1.70
CO_2	.08	.18	.19	1.42
	100.31	100.54	100.11	99.73

4TH. SCHIST FROM THE ARAGON IRON MINE.

Talcose-schist. Description, hitherto unpublished, furnished by W. S. Bayley. Analysis by George Steiger, record No. 1835. Consists mainly of talc and quartz, with a little limonite and other iron oxides.

SiO_2	49.56	H_2O at 110°	4.50
Al_2O_3	10.12	H_2O above 110°	7.66
Fe_2O_3	5.87	TiO_2	.60
FeO	.13	P_2O_5	.04
MgO	20.53	MnO	trace
CaO	.72	CO_2	none
Alkalies	none		99.73

4. PENOKEE-GOGEBIC REGION.

Rocks mostly described by Van Hise in Mon. XIX. Analyses A to G r T. M. Chatard, record Nos. 991, 992, 993, 994, 905.

A. Diabase, near SE. corner of sec. 13, T. 47 N., R. 46 W., Michi- in. Contains plagioclase, augite, magnetite, apatite, and olivine, with me ilmenite and leucoxene. P. R. C. 1001.

B. Same dike as A, partly altered. The pyroxene is altered to aphibole, and the latter partly to biotite. Biotite has also been rived from feldspar. P. R. C. 1000.

C. Feldspar separated from A.

D. Altered diabase, Aurora mine, NE. ¼ of SW. ¼ of sec. 23, T. 47 ., R. 47 W., Michigan. P. R. C. 1002.

	A.	B.	C.	D.
SiO_2	47.90	46.85	51.18	41.60
Al_2O_3	15.60	22.62	27.00	37.20
Fe_2O_3	3.69	5.12	3.19	3.21
FeO	8.41	1.58	undet.	.30
MgO	8.11	2.01	1.92	.02
CaO	9.99	1.25	11.70	.23
Na_2O	2.05	.80	3.48	.07
K_2O	.23	2.66	.41	
H_2O at 105°	.15	3.12	1.19	.29
H_2O above 105°	2.34	8.25		13.54
TiO_2	.82	1.12		3.79
P_2O_5	.13	.16		.14
Cr_2O_3	trace			
MnO	.17	2.54	.17	.08
NiO	.10	.08		
BaO	.05	.10		trace
CO_2	.38	1.89		.38
	100.12	100.15	100.24	100.85

E. Feldspar separated from gabbro, southern half of sec. 14, T. 44 N., R. 4 W., Wisconsin.

F, G. Feldspars separated from olivine-diabase, NE. ¼ of sec. 13, T. 45 N., R. 1 W., Wisconsin.

	E.	F.	G.
SiO_2	51.99	61.65	56.15
Al_2O_3	29.32	19.91	26.05
Fe_2O_3	1.23	2.28	1.98
FeO		undet.	undet.
MgO	.63	.61	.54
CaO	12.60	4.12	8.70
Na_2O	2.91	4.74	4.79
K_2O	.28	5.72	1.56
H_2O at 105°	.03	.95	.13
H_2O above 105°	.54		.64
MnO	trace	trace	.13
	99.53	99.98	100.67

The following analyses, by W. F. Hillebrand, of separations from e gabbro of Ashland County, Wisconsin, were made for the late R. . Irving, but were never published by him:

H. Magnetite, record No. 687. Partial analysis.

I. Feldspar, record No. 688.

J. Diallage, record No. 686.

For convenience I also include here, although it is decidedly out of assification—

K. Graywacke, Hurley, Wisconsin. Described by Bayley in Bull. 0, p. 84. Analysis by H. N. Stokes, record No. 1314. Contains artz, feldspars, iron oxides, and probably kaolin. In the cement e chlorite, quartz, magnetite, pyrite, rutile, occasionally biotite, and ther muscovite or kaolin. P. R. C. 20.

	H.	I.	J.	K.
SiO_2	....	53.30	49.80	76.84
Al_2O_3	....	29.03	2.86	11.76
Fe_2O_3	50.29	.55	2.48	.55
FeO	30.70	.23	10.82	2.8[illegible]
MgO	....	.13	15.33	1.39
CaO	....	11.40	16.50	.70
Na_2O	....	4.87	.51	2.57
K_2O	....	.40	.12	1.62
H_2O	....	.23	.33	1.87
TiO_2	8.77	trace	1.29	....
P_2O_5	....	trace	trace	....
MnO	....	none	.37	trace
SrO	....	trace	none	....
BaO	....	trace	none	....
Li_2O	....	none	trace?	....
	89.46	100.14	100.41	100.18

5. ROCKS OF PIGEON POINT, MINNESOTA.

Described by Bayley in Bull. 109. Also partially in Amer. Journ. Sci., 3d series, vol. 37, p. 54. A and B are also described in Bull. 150, p. 274.

A. Olivine diabase. Contains labradorite, olivine, pyroxene, apatite, and magnetite. Analysis by W. F. Hillebrand, record No. 496.

B. Diallage separated from diabase. Partial analysis by R. B. Riggs, record No. 607.

C. Rock lying between the diabase and the adjacent red porphyry. Contains red feldspar, quartz, hornblende, chlorite, magnetite, apatite, and rutile. Analysis by W. F. Hillebrand, record No. 500. P. R. C. 1018.

	A.	B.	C.
SiO_2	49.88	48.34	57.98
Al_2O_3	18.55	2.90	13.58
Fe_2O_3	2.06	4.68	3.11
FeO	8.37	14.15	8.68
MgO	5.77	11.34	2.87
CaO	9.72	15.10	2.01
Na_2O	2.59	....	3.56
K_2O	.68	....	3.44
H_2O	1.04	....	2.47
TiO_2	1.19	1.98	1.75
P_2O_5	.16	....	.29
ZrO_2	none	....	....
MnO	.09	....	.13
SrO	trace	....	trace
BaO	.02	....	.04
Li_2O	none	....	trace
Cl	trace	....	trace
	100.12	98.49	99.91

D. Red soda-granite. Contains feldspar, quartz, chlorite, some muscovite, rutile, leucoxene, hematite and apatite, with sometimes secondary calcite. Granular variety. Analysis by W. F. Hillebrand, record No. 495. Dried at 110°.

E. Same as D, porphyritic variety. Called by Bayley a quartz-keratophyre. Analysis by Hillebrand, record No. 497.

F. Similar red porphyry, Little Brick Island, Lake Superior, near Pigeon Point. Consists chiefly of feldspar and quartz, with augite occasionally present. Analysis by L. G. Eakins, record No. 1059.

G. Red feldspar, anorthoclase, separated from D. Contains hematite inclusions. Analysis by J. E. Whitfield, record No. 521. Dried at 104°.

	D.	E.	F.	G.
SiO_2	72.42	74.00	73.70	65.00
Al_2O_3	13.04	12.04	12.87	18.22
Fe_2O_3	.68	.78	3.76	2.64
FeO	2.49	2.61	.31	
MgO	.58	.42	.11	.06
CaO	.66	.85	.14	1.06
Na_2O	3.44	3.47	3.63	8.40
K_2O	4.97	4.33	4.56	4.18
H_2O	1.21	.86	.57	.46
TiO_2	.40	.34	.12	
P_2O_5	.20	.06	trace	
MnO	.09	.05	.07	
SrO	trace?	trace		
BaO	.15	.12		
Li_2O	trace?	trace?		
Cl	trace	trace		
	100.33	99.93	99.84	100.02

H. Dark vitreous quartzite. Contains quartz, a little red feldspar, some chlorite, some green mica, a few scales of biotite, and grains of magnetite. P. R. C. 1007.

I. Lighter interbedded quartzite. Feldspar in it much altered. P. R. C. 1004.

J. Epidotic quartzite. P. R. C. 1023.

K. Unaltered quartzite. P. R. C. 1006.

Analyses by R. B. Riggs, record Nos. 569, 571, 572, 575. Material dried at 105°.

	H.	I.	J.	K.
SiO_2	74.22	73.65	73.14	73.64
Al_2O_3	10.61	11.08	12.60	11.25
Fe_2O_3	7.45	7.24	7.57	6.24
FeO	.85	.77	1.31	1.04
MgO	1.48	1.52	1.67	1.57
CaO	.56	.40	.43	.36
Na_2O	2.12	1.67	1.78	3.04
K_2O	1.08	1.65	1.00	1.42
Ign	1.79	1.88	.83	1.98
TiO_2	.16	trace?	.04	trace
MnO	none	trace	trace	none
	100.32	99.86	100.37	100.54

Ba and Sr not looked for.

L. Altered quartzite. Contains more fibrous chlorite, some sericite, a little kalin and biotite, grains of magnetite, earthy matter, and sometimes a little calcite. Analysis by R. B. Riggs, record No. 570. P. R. C. 1009.

M. Mottled quartzite. Analysis by Riggs, record No. 578. P. R. C. 1021.

N. Purplish slate, containing many small crystals of red feldspar and scales of mica. Analysis by J. E. Whitfield, record No. 520. P. R. C. 1024.

O. Very slightly altered slate. Analysis by Riggs, record No. 576. P. R. C. 1011.

Material for analysis dried at 104°–105°.

	L.	M.	N.	O.
SiO_2	71.00	72.25	63.82	59.71
Al_2O_3	12.88	10.73	14.65	18.32
Fe_2O_3	6.69	8.01	3.16	8.11
FeO	.65	.38	5.12	.85
MgO	1.68	1.85	2.08	3.54
CaO	.21	.42	.70	1.05
Na_2O	1.43	2.03	1.95	1.93
K_2O	2.95	2.56	2.81	3.43
H_2O	2.03	2.05	2.62	3.24
TiO_2	.44	trace	2.66	trace
P_2O_5			.19	
MnO	trace	trace	none	none
Li_2O			none	
SO_3			.33	
	99.96	100.28	100.09	100.18

Ba and Sr not looked for.

P. Red granitic rock resembling D, but with more dark spots, found in contact with the purplish slate, N. Consists mainly of red feldspar, quartz, and chlorite. Analysis by J. E. Whitfield, record No. 519. Dried at 104°. P. R. C. 1014.

Q. Groundmass of red mottled quartzite. Analysis by W. F. Hillebrand, record No. 499. P. R. C. 1022.

R. Green mottlings from Q. Mostly quartz and sericite. Analysis by Hillebrand, record No. 498.

S. Another sample of the green mottlings, selected with especial care. Analysis by L. G. Eakins, record No. 1058.

T. Brilliantly red vitreous quartzite. Analysis by R. B. Riggs, record No. 574. Dried at 105°. P. R. C. 1008.

	P.	Q.	R.	S.	T.
SiO_2	68.36	76.57	77.70	83.27	83.69
Al_2O_3	13.76	9.21	7.67	7.81	7.50
Fe_2O_3	2.65	1.67	3.55	1.99	1.81
FeO	2.75	3.94	3.29	1.81	.38
MgO	.68	1.51	1.83	1.59	.35
CaO	.70	.73	.26	.20	.39
Na_2O	3.56	3.07	1.96	.19	2.46
K_2O	4.48	1.02	1.04	1.11	2.61
H_2O	.98	1.89	[a]2.36	2.32	.72
TiO_2	1.57	.42	.30	trace	trace?
P_2O_5	.33	trace	none	trace	
ZrO_2		none			
MnO	trace	.05	.04		trace
SrO	undet.	trace?	(?)		undet.
BaO	undet.	none	none		undet.
Li_2O	none	trace	trace		
SO_3	.66				
	100.48	100.08	100.00	100.29	99.91

[a] Determined by difference.

6. MISCELLANEOUS ROCKS FROM MINNESOTA.

A. Granulitic hypersthene-gabbro, from SE. ¼ sec. 20, T. 65 N., R. 4 W. Described by Bayley, Journal of Geology, vol. 3, p. 1. Contains hypersthene, biotite, diallage, magnetite, and plagioclase. Poor in feldspar. Analysis by H. N. Stokes, record No. 1267.

B. Hypersthene from A. Analysis by E. A. Schneider, record No. 1358.

C. Granulitic diallage-gabbro, SE. ¼ of NW. ¼ of sec. 26, T. 64 N., R. 8 W. Described by Bayley, Journal of Geology, vol. 3, p. 1. Contains diallage, hypersthene, magnetite, and plagioclase. Analysis by W. H. Melville, record No. 1403.

D. Olivine-gabbro, west side of Birch Lake, SE. ¼ of sec. 19, T. 63 N., R. 4 W. Described by Bayley, Journal of Geology, vol. 1, p. 688. Contains a large proportion of diallage and olivine. Analysis by Stokes, No. 1267.

E. Olivine from D. Analysis by W. F. Hillebrand, record No. 1308.

	A.	B.	C.	D.	E.
SiO_2	46.96	48.44	49.56	45.66	35.58
Al_2O_3	14.13	7.91	17.81	16.44	.92
Fe_2O_3	.76	.33	2.76	.66	33.91
FeO	14.95	20.88	9.48	13.90	
MgO	15.97	19.35	5.93	11.57	26.86
CaO	2.32	1.44	9.70	7.23	.90
Na_2O	.35		2.87	2.13	
K_2O	1.68			.41	
H_2O at 105°	.07	.08	.50	.07	.11
H_2O above 105°	1.26	none		.83	.20
TiO_2	.62	undet.	.48	.92	1.22
P_2O_5	.03		.67	.05	
Cr_2O_3	trace			trace	trace
MnO	.93	.92	.06	trace	.35
CoO					.20
NiO	.06			.16	
CO_2			trace		
	100.09	99.35	99.82	100.03	100.25

F. Average gabbro, south quarter post, sec. 35, T. 61 N., R. 12 W. Described by Bayley in Journal of Geology, vol. 1, p. 688. Contains plagioclase, olivine, pyroxene, and magnetite. Analysis by H. N. Stokes, record No. 1267.

G. Feldspar from preceding gabbro. Analysis by W. F. Hillebrand, record No. 1308.

H. Feldspar from gabbro, east side of North Fowl Lake. Analysis by Hillebrand, No 1308.

I. Feldspar from gabbro, NW. ¼ of SE. ¼ of sec. 23, T. 62 N., R. 10.

J. Feldspar from gabbro, center of sec. 25, T. 64 N., R. 8.

K. Feldspar from gabbro, Duluth and Iron Range Railroad.

Analyses I, J, and K by Hillebrand, record No. 1115.

H, I, J, and K analyzed for W. S. Bayley, but analyses hitherto unpublished.

	F.	G.	H.	I.	J.	K.
SiO_2	46.45	51.89	62.71	52.50	52.61	53.45
Al_2O_3	21.30	29.68	19.20	30.15	29.80	29.77
Fe_2O_3	.81	.32	1.08	.47	.57	.33
FeO	9.57	.37	.93	.15	.23	.15
MgO	7.90	.38	.81	.10	.20	.11
CaO	9.83	12.62	.44	12.82	12.25	11.33
Na_2O	2.14	3.87	2.96	3.72	3.80	4.33
K_2O	.34	.50	10.41	.53	.53	.68
H_2O at 100°	.14	.07	.23	.25	.29	.23
H_2O above 100°	1.02	.39	.92			
TiO_2	1.19		trace	trace	trace	trace
P_2O_5	.02					
NiO	.04					
MnO	trace		trace		trace	
SrO			trace			
	100.75	100.09	99.69	100.69	100.28	100.38

L. Garnetiferous gabbro, Granite Falls. Described by W. S. Bayley in Bull. 150, p. 282. Contains plagioclase, augite, garnet, magnetite, a little hornblende, some quartz grains, and apatite. Analysis by H. N. Stokes, record No. 1296. Sp. gr. 3.105. P. R. C. 109.

M. Gabbro-diorite, Minnesota Falls. Described by Bayley in Bull. 150, p. 369. Essentially plagioclase and hornblende, with some kaolin, augite, and biotite. Analysis by Stokes, No. 1296. Sp. gr. 2.935. P. R. C. 144.

N. Quartz-norite-gneiss, Odessa. Described by Bayley in Bull. 150, p. 358. Contains quartz, plagioclase, pyroxene, biotite, garnet, magnetite, and sulphide of iron. Analysis by Stokes, No. 1296. Sp. gr. 2.770.

O. Mica-schist, bed of Cross River, near Gunflint Lake. Description furnished by C. R. Van Hise. Contains biotite, quartz, feldspar (?), and pyrites. Analysis by T. M. Chatard, record No. 896.

P. Actinolite-magnetite-schist, SE. ¼ of SE. ¼ of sec. 34, T. 61 N., R. 12 W. Described by Bayley in Amer. Journ. Sci., 3d series, vol. 46, p. 178. Mainly actinolite and magnetite. Analysis by W. H. Melville, record No. 1403.

Q. Magnetite rock near the preceding, also described with P by Bayley. Analysis by Melville, No. 1403.

	L.	M.	N.	O.	P.	Q.
SiO_2	52.31	48.29	61.04	64.77	12.35	1.16
Al_2O_3	18.35	20.87	16.97	14.45	.10	1.81
Fe_2O_3	5.90	1.13		1.84	58.68	69.08
FeO	11.06	4.93	5.58	4.54	21.34	27.10
MgO	1.00	7.54	3.62	2.34	4.08	.25
CaO	7.33	14.32	5.99	2.33	1.91	.53
Na_2O	2.90	1.77	1.96	1.37	trace	
K_2O	.49	.38	.55	5.03		
H_2O at 105°	.35	.89	.43	.07	.19	
H_2O above 105°				1.92		
TiO_2				.60	.12	none
P_2O_5				.20	.25	.06
MnO				.11	1.22	.33
SO_3				.60		
CO_2				.41		
FeS			[a]3.73			
	99.69	100.12	99.87	100.58	100.24	100.32

[a] Probably pyrrhotite.

SOUTH DAKOTA.

A. Phonolite, Black Hills. Described by Whitman Cross in Bull. 150, p. 191. Contains sanidine, nephelite, ægirite, nosean, and sodalite, with accessory sphene, apatite, and zircon, and possibly some rare zirconates or titanates. Also, sparingly, secondary zeolites and calcite. No magnetite, but minute ferritic flakes are disseminated through the rock. Analysis by W. F. Hillebrand, record No. 1618. P. R. C. 73.

B. An earlier analysis of A, by H. N. Stokes, record No. 1314. This was made along the ordinary lines as regards "completeness," as requested by the collector, and without regard to minor accessory constituents. It serves well to illustrate the difference between the two modes of treatment, in comparison with the fuller analysis.

C. Tourmaline-biotite-schist, north of Harney Peak, Black Hills. Described by Bayley in Bull. 150, p. 327. Contains quartz, biotite, tourmaline, a little garnet and rarely muscovite, iron ore, and apatite. Analysis by Stokes, record No. 1296. P. R. C. 130.

	A.	B.	C.
SiO_2	57.86	58.60	66.77
Al_2O_3	20.26	20.98	17.65
Fe_2O_3	2.35	2.22	1.55
FeO	.39	.44	3.29
MgO	.04	.33	2.13
CaO	.89	1.13	.56
Na_2O	9.47	8.38	.99
K_2O	5.19	5.49	4.49
H_2O at 110°	.21	1.92	1.89
H_2O above 110°	2.40		
TiO_2	.22		
P_2O_5	.03		
ZrO_2	.15		
MnO	.21	.20	
SrO	.04		
BaO	.09		
Li_2O	trace		
SO_3	.06		
S	.03		
Cl	.08		
F	(?)		
CO_2	none		
	99.97	99.69	99.32

WYOMING.

Rocks studied by Whitman Cross. The Leucite Hills series is described in Amer. Jour. Sci., 4th ser., vol. 4, p. 115. Analysis J is by L. G. Eakins, record No. 1078. The others are by W. F. Hillebrand, one made in the Denver laboratory, and record Nos. 343, 355, 362, 368, 403, 463, 1668, and 1682.

A. Wyomingite, Boars Tusk, Leucite Hills. Contains phlogopite, leucite, diopside, and apatite. Sp. gr. 2.779, 13.5°. P. R. C. 567.

B. Wyomingite, Fifteenmile Spring, Leucite Hills. Composition like A. Sp. gr. 2.627, 30°. P. R. C. 566.

C. Portion of B soluble in 2.5 per cent nitric acid.

D. Phlogopite from wyomingite.

E. Madupite, Pilot Butte, Leucite Hills. Contains predominating diopside and phlogopite, with perofskite and magnetite, in a glassy base which has approximately the composition of leucite. Sp. gr. 2.857, 22°. P. R. C. 576.

	A.	B.	C.	D.	E.
SiO_2	50.23	53.70	6.08	42.56	42.65
Al_2O_3	11.22	11.16	.91	12.18	9.14
Fe_2O_3	3.34	3.10	.50	2.73	5.13
FeO	1.84	1.21		.90	1.07
MgO	7.09	6.44	1.51	22.40	10.89
CaO	5.99	3.46	2.13	.20	12.36
Na_2O	1.37	1.67	.28	.44	.90
K_2O	9.81	11.16	1.21	10.70	7.99
H_2O at 110°	.93	.80	(?)	....	2.04
H_2O above 110°	1.72	2.61	(?)	2.35	2.18
TiO_2	2.27	1.92	.21	2.09	1.64
P_2O_5	1.89	1.75	1.54	.06	1.52
Cr_2O_3	.10	.04	....	.73	.07
Di_2O_3, etc. *a*	.03	none	....	....	.11
MnO	.05	.04	....	....	.12
SrO	.24	.19	.10	trace	.33
BaO	1.23	.62	.14	1.00	.89
Li_2O	trace	trace	....	trace	trace
SO_3	.74	.06	.06	....	.58
Cl	.03	.03	.03	....	.03
F	.50	.44	....	2.46	.47
	100.62	100.40	14.70	100.80	100.11
Less O	.22	.19	....	1.03	.20
	100.40	100.21	....	99.77	99.91

a Probably contains other rare earths.

F. Orendite, Fifteenmile Spring, Leucite Hills. Contains predominating leucite and sanidine, with phlogopite, a little biotite, diopside, and amphibole, and accessory apatite and rutile. Sp. gr. 2.686, 23.5°.

G. Orendite, North Table Butte, Leucite Hills. Composition like F. Sp. gr. 2.699, 19°.

H. Groundmass of F. Sp. gr. 2.615, 19°. Not cited in published paper.

I. Diopside separated from mixed wyomingite and madupite. Sp. gr. 3.290, 20°. Analyzed in the Denver laboratory. P_2O_5 included with TiO_2.

J. Dacite?, Garfield Peak. Phenocrysts of plagioclase and hornblende, with microscopic sphene and apatite in a groundmass containing plagioclase, orthoclase, quartz, and magnetite. Sp. gr. 2.576, 26.2°. P. R. C. 159.

	F.	G.	H.	I.	J.
SiO_2	54.08	54.17	58.13	50.86	67.78
Al_2O_3	9.47	10.16	11.72	....	16.67
Fe_2O_3	3.19	3.34	3.01	1.19	1.99
FeO	1.03	.65	1.01	1.82	.51
MgO	6.74	6.62	5.79	17.42	.71
CaO	3.55	4.19	2.24	23.32	2.67
Na_2O	1.39	1.21	1.36	.76	4.91
K_2O	11.76	11.91	12.58	.42	3.43
H_2O at 110°	.79	.52	.99	....	1.44
H_2O above 110°	2.71	1.01	1.16	.31	
TiO_2	2.08	2.67	1.48	3.03	....
P_2O_5	1.36	1.59	.32	....	.19
ZrO_2	undet.	.22	undet.	....	....
V_2O_3	.02	....	....	....	....
Cr_2O_3	.07	.05	....	....	....
NiO	....	trace	....	....	....
MnO	.05	.06	trace	.03	trace
SrO	.20	.18	.10	....	....
BaO	.67	.59	.29	....	....
Li_2O	trace	trace	trace	....	....
SO_3	.29	.16	.13	....	....
CO_2	....	.49	....	....	....
Cl	.04	.06	trace	....	....
F	.49	.36	trace	....	....
	99.98	100.21	100.31	99.16	100.30
Less O	.21	.17	....	....	....
	99.77	100.04	....	....	....

YELLOWSTONE NATIONAL PARK AND THE ABSAROKA RANGE.

1. ELECTRIC PEAK.

Rocks described by Iddings in 12th Ann., p. 577. Also in Bull. Phil. Soc. Washington, vol. 11, p. 206. For analyses O, P, see Mon. XXXII, Pt. II.

A. Pyroxene-mica-diorite. Contains augite, hypersthene, plagioclase, quartz, biotite, hornblende, magnetite, and apatite. Analysis by J. E. Whitfield, record No. 830. P. R. C. 94.

B. Pyroxene-mica-diorite. Same minerals as under A. Analysis by Whitfield, No. 921.

C. Pyroxene-mica-diorite. Like A and B. Analysis by W. H. Melville, record No. 1231.

D. Pyroxene-porphyry. Contains augite, hypersthene, biotite, magnetite, plagioclase, and quartz. Analysis by Whitfield, No. 830.

E. Quartz-pyroxene-mica-diorite. Contains biotite, hornblende, augite, hypersthene, magnetite, plagioclase, orthoclase, and quartz. Analysis by Melville, No. 1231.

	A.	B.	C.	D.	E.
SiO_2	56.28	58.05	61.22	57.38	64.07
Al_2O_3	14.23	18.00	16.14	16.86	15.82
Fe_2O_3	4.69	2.49	3.01	2.49	3.40
FeO	4.05	4.56	2.58	5.17	1.44
MgO	6.37	3.55	4.21	5.51	3.39
CaO	7.94	6.17	5.46	7.32	4.43
Na_2O	2.98	3.64	4.48	3.33	4.06
K_2O	1.23	2.18	1.87	1.45	2.27
H_2O at 100°	.93	.86	.04	.42	.10
H_2O above 100°			.40		.42
TiO_2	.84	1.05	.61	trace	.45
P_2O_5	.40	.17	.25	trace	.18
MnO	.16	none	trace	trace	trace
NiO	....	....	.09	....	.05
Li_2O	.01	none	....	.39	....
SO_3	trace	.07	....	.21	....
Cl	.17	trace	....	.17	....
	100.28	100.79	100.36	100.70	100.08

F. Quartz-mica-diorite. Contains biotite, hornblende, augite, hypersthene, plagioclase, orthoclase, and quartz. Analysis by Whitfield, No. 921.

G. Quartz-mica-diorite. Contains biotite, hornblende, plagioclase, pyroxene, quartz, and orthoclase. Analysis by Whitfield, No. 921.

H, I, J. Quartz-mica-diorites. Contain hornblende, biotite, plagioclase, orthoclase, and quartz. Analyses by Whitfield, Nos. 921 and 830.

	F.	G.	H.	I.	J.
SiO_2	65.11	65.60	64.85	66.05	67.54
Al_2O_3	16.21	17.61	16.57	16.96	17.02
Fe_2O_3	1.06	.95	2.10	2.59	2.97
FeO	3.19	2.76	2.15	1.38	.34
MgO	2.57	1.49	2.14	2.08	.13
CaO	3.97	3.72	4.01	3.37	3.36
Na_2O	4.00	4.36	3.71	4.20	4.62
K_2O	2.51	2.36	3.10	2.53	2.28
H_2O	.94	.59	.35	.69	.55
TiO_2	.71	.75	.91	.34	.80
P_2O_5	.02	.16	.14	trace	trace
MnO	none	none	none	none	trace
Li_2O	.04	.03	none	none	.03
SO_3	trace	trace	trace	.03	.26
Cl	none	none	none	trace	.15
	100.33	100.38	100.03	100.22	100.05

K. Quartz-mica-diorite-porphyry. Contains biotite, hornblende, plagioclase, orthoclase, and quartz. Analysis by Whitfield, No. 830.

L. Quartz-mica-diorite-porphyry. Contains quartz, biotite, plagioclase, alkali-feldspar, and hornblende. Analysis by Whitfield, No. 830.

M. Hornblende-porphyry; intrusive sheet. Contains hornblende, plagioclase, magnetite, and quartz. Analysis by Whitfield, No. 429.

N. Hornblende-mica-porphyry; intrusive sheet. Contains hornblende, plagioclase, biotite, magnetite, and quartz. Analysis by Whitfield, No. 420. The Indian Creek laccolith.

O. Augite-andesite-porphyry; intrusive sheet, upper portion. Contains malacolite, plagioclase, probably orthoclase, magnetite, and little biotite, with secondary chlorite or serpentine and actinolite. Analysis by Whitfield, No. 830.

P. Same sheet as O, lower portion. Analysis by W. F. Hillebrand, record No. 1571. Contains 0.04 V_2O_3.

	K.	L.	M.	N.	O.	P.
SiO_2	65.97	69.24	58.49	61.50	52.10	50.59
Al_2O_3	16.53	15.30	16.70	17.42	16.34	11.53
Fe_2O_3	2.59	1.72	3.85	4.66	3.84	1.83
FeO	1.72	.69	2.37	1.09	6.82	7.64
MgO	2.11	.95	3.12	1.26	4.33	11.27
CaO	3.37	2.98	5.90	5.33	4.73	8.79
Na_2O	3.41	4.46	3.47	3.99	4.02	2,27
K_2O	2.67	2.52	1.59	1.29	4.20	2.33
H_2O at 110°	1.23	1.30	2.44	2.44	1.74	.21
H_2O above 110°						1.76
TiO_2	.42	.65	1.71	none	.79	.80
P_2O_5	trace	trace	trace	.60	.68	.48
MnO	none	trace	.24	trace	trace	.17
NiO	....	....	....	....	....	.06
SrO	....	....	....	....	....	.03
BaO	....	....	....	....	....	.10
Li_2O	.09	none	.01	.03	.13	trace
SO_3	.13	.27	.63	.35	.22	none
Cl	.09	trace	....	....	.24	trace
	100.33	100.08	100.52	99.96	100.18	99.86
O=Cl	.02	....	....	....	.05	
	100.31	....	....	....	100.13	

2. SEPULCHRE MOUNTAIN.

Rocks described by Iddings, 12th Ann., p. 633. Also in Bull. Phil. Soc. Washington, vol. 11, p. 210, and in Mon. XXXII, Pt. II.

A. Pyroxene-andesite. Essentially composed of augite, hypersthene, and plagioclase. Analysis by J. E. Whitfield, record No. 923.

B. Pyroxene-andesite. Composition like A. Analysis by Whitfield, No. 923.

C. Hornblende-andesite. Essentially plagioclase and hornblende. Analysis by Whitfield, No. 922.

D. Hornblende-pyroxene-andesite. Contains augite, hypersthene, plagioclase, and hornblende. Analysis by T. M. Chatard, record No. 712.

E. Hornblende-pyroxene-andesite. Minerals as in D, with magnetite also. Analysis by Chatard, No. 712.

	A.	B.	C.	D.	E.
SiO_2	55.83	57.17	55.92	56.61	60.30
Al_2O_3	17.11	17.25	17.70	13.62	16.31
Fe_2O_3	4.07	2.48	3.16	5.89	4.35
FeO	3.75	4.31	4.48	2.60	1.41
MgO	5.05	4.83	4.34	5.48	2.39
CaO	7.40	6.61	5.90	6.61	5.62
Na_2O	2.94	3.44	4.08	3.13	3.99
K_2O	1.71	2.03	2.24	2.71	2.36
H_2O at 105°	1.28	1.20	1.42	1.20	.64
H_2O above 105°				1.07	1.86
TiO_2	1.05	1.03	.94	.79	.76
P_2O_5	.21	.05	.18	.06	.20
Cr_2O_3	....	....	....	.05	trace?
MnO	none	none	trace	.35	.13
BaO	....	....	....	.14	.15
SrO	....	....	....	Trace	Trace
Li_2O	none	trace	.09	....	....
SO_3	trace	trace	trace	(?)	.10
Cl	none	trace	none	....	....
	100.40	100.40	100.45	100.31	100.57

F. Hornblende-mica-andesite. Contains plagioclase, hornblende, biotite, and magnetite. Analysis by Whitfield, No. 924.

G. Hornblende-mica-andesite. Contains plagioclase, hornblende, and biotite. Analysis by Chatard, No. 712.

H. Dacite. Contains plagioclase, hornblende, biotite, and quartz. Analysis by Whitfield, No. 830.

I. Dacite. Minerals as in H. Analysis by L. G. Eakins, record No. 1135.

J. Andesite-breccia. Not in paper cited. See Mon. XXXII, Pt. II. Analysis by Chatard, No. 712. Reported by Iddings as hornblende-mica-andesite, containing hornblende, plagioclase, quartz, biotite, and a little magnetite.

	F.	G.	H.	I.	J.
SiO_2	64.27	65.50	65.66	67.49	67.95
Al_2O_3	17.84	14.94	15.61	16.18	14.98
Fe_2O_3	3.36	1.72	2.10	1.30	2.33
FeO	1.29	2.27	2.07	1.22	.95
MgO	2.00	2.97	2.46	1.34	1.42
CaO	3.42	2.33	3.64	2.68	3.98
Na_2O	3.84	5.46	3.65	4.37	4.39
K_2O	2.48	2.76	2.03	2.40	2.86
H_2O at 105°	1.32	.24	1.07	2.69	.37
H_2O above 105°		1.13			.61
TiO_2	.32	.45	1.37	.13	.45
P_2O_5	.16	.09	trace	.13	.07
MnO	none	.20	none	.08	.09
BaO	....	.13	....	....	.23
SrO	....	trace?	....	....	trace?
Li_2O	.03	....	.36	....	....
SO_3	trace	.06	.13	....	.11
Cl	none	....	.12	....	....
	100.33	100.25	100.27	100.01	100.79

3. ABSAROKA RANGE.

1ST. CRANDALL BASIN.

Rocks described by Iddings in Mon. XXXII, Pt. II. The analyses also appeared in Bull. Phil. Soc. Washington, vol. 12, p. 204.

A. Gabbro-porphyry, Hurricane Ridge. Contains augite, plagioclase, hypersthene, biotite, magnetite, and a little olivine. Analysis by L. G. Eakins, record No. 1089.

B. Basalt flow, north side of Timber Creek. Rich in olivine, augite, and magnetite. Analysis by Eakins, No. 1087.

C. Basalt dike, ridge south of Hurricane Ridge. Like B. Contains also labradorite and a little orthoclase. Analysis by Eakins, No. 1087.

D. Mica-gabbro-porphyry, Hurricane Ridge. Contains plagioclase, augite, hypersthene, biotite, and magnetite. Analysis by Eakins, No. 1089.

E. Mica-gabbro, Hurricane Ridge. Like D, with some orthoclase and a little quartz and olivine. Analysis by Eakins, No. 1089.

F. Basalt-glass-breccia, ridge south of Indian Peak. A glass showing crystals of olivine, augite, plagioclase, and magnetite. Analysis by Eakins, No. 1087.

	A.	B.	C.	D.	E.	F.
SiO_2	51.81	52.09	52.11	53.56	53.71	53.89
Al_2O_3	15.24	17.84	16.58	16.07	18.00	18.81
Fe_2O_3	3.66	4.27	3.66	3.21	3.99	4.92
FeO	4.86	4.56	4.99	5.29	4.05	2.81
MgO	8.89	5.33	6.87	7.23	5.19	3.29
CaO	9.06	8.03	6.43	8.77	6.88	5.42
Na_2O	2.83	3.39	3.25	3.06	3.50	3.65
K_2O	2.08	1.98	3.20	1.94	3.10	2.98
H_2O	.67	1.77	1.99	.19	.55	2.99
TiO_2	.77	.39	.53	.68	.74	.49
P_2O_5	.18	.27	.63	.18	.38	.52
MnO	.08	.14	.23	.11	.24	.17
	100.13	100.06	100.47	100.29	100.33	99.94

G. Orthoclase-gabbro-diorite, rich in mica, Hurricane Ridge. Contains orthoclase,plagioclase, quartz, biotite, augite, hypersthene, magnetite, and hornblende. Analysis by Eakins, No. 1089.

H. Another sample, like G. Same analyst and record number.

I. Dioritic facies of gabbro, Hurricane Ridge. Very feldspathic. Same analyst and number.

J. Monzonite, Hurricane Ridge. Contains orthoclase, plagioclase, biotite, augite, hypersthene, and magnetite. Analysis by W. H. Melville, record number 1233.

K. Augite-andesite-porphyry, intrusive sheet, Hurricane Ridge. Analysis by Eakins, No. 1088. Contains plagioclase, augite, hypersthene, magnetite, biotite, quartz, and microscopic orthoclase.

	G.	H.	I.	J.	K.
SiO_2	55.93	56.21	57.26	57.32	57.64
Al_2O_3	18.32	18.24	19.40	17.29	18.43
Fe_2O_3	2.39	3.26	2.49	3.89	3.63
FeO	4.91	3.69	3.29	3.03	2.84
MgO	3.97	3.38	2.57	3.56	3.32
CaO	6.17	5.91	5.68	5.81	5.49
Na_2O	4.29	4.15	4.21	3.89	4.03
K_2O	2.62	3.02	2.95	3.04	3.33
H_2O at 100°	.22	.78	.86	.33	.51
H_2O above 100°				.30	
TiO_2	.81	.88	.76	.62	.77
P_2O_5	.56	.64	.51	.50	.34
MnO	.14	.17	.16	.06	.10
NiO	....	....	....	.10	....
Cl	....	....	....	....	trace
	100.33	100.33	100.14	99.74	100.43

L. Hornblende-mica-andesite-porphyry dike, ridge south of Hurricane Ridge. Contains plagioclase, hornblende, biotite, augite, hypersthene, and magnetite, with a little chlorite or serpentine. Analysis by Eakins, No. 1087.

M. Quartz-diorite-porphyry, Hurricane Ridge. Contains plagioclase, orthoclase, quartz, augite, hypersthene, magnetite, and a little biotite. Analysis by Melville, No. 1234.

N. Quartz-mica-diorite, Hurricane Ridge. Contains andesine, orthoclase, quartz, biotite, hornblende, magnetite, and a little pyroxene. Analysis by Melville, No. 1234.

O. Quartz-mica-diorite-porphyry, Hurricane Ridge. Contains andesine, orthoclase, quartz, and biotite. Analysis by Melville, No. 1234.

P. Aplite dike, Hurricane Ridge. Contains quartz, orthoclase, oligoclase, biotite, magnetite, some chlorite, and a little hornblende. Analysis by Eakins, No. 1088.

	L.	M.	N.	O.	P.
SiO_2	61.16	63.42	63.97	64.40	71.62
Al_2O_3	16.17	17.16	15.78	15.77	14.99
Fe_2O_3	2.89	3.09	2.35	2.47	1.27
FeO	2.18	1.50	1.87	1.15	1.01
MgO	3.89	1.64	2.84	2.12	.74
CaO	4.26	4.65	3.71	3.54	1.33
Na_2O	3.87	4.51	4.36	4.10	3.62
K_2O	3.20	3.04	4.01	3.81	4.81
H_2O at 100°	2.09	.16	.09	.31	.41
H_2O above 100°		.28	.49	1.93	
TiO_2	.23	.35	.48	.40	.08
P_2O_5	.13	.26	.40	.16	trace
MnO	trace	.04	.05	.04	.17
NiO	....	.19	trace	.17	....
Cl	....	....	....	....	trace
	100.07	100.29	100.40	100.27	100.05

2D. SUNLIGHT INTRUSIVES.

Descriptions, hitherto unpublished, supplied by Arnold Hague and T. A. Jaggar, jr. Analyses A, B, and C by W. F. Hillebrand, record No. 1801; D by H. N. Stokes, No. 1804.

A. Quartz-syenite, Copper Creek Basin. Contains biotite, hornblende, epidote, orthoclase, augite, titanite, magnetite, and apatite. Hornblende very pale in color.

B. Syenite-porphyry, Sulphur Creek Basin. Contains oligoclase and biotite, in a groundmass of quartz and feldspar.

C. Augite-syenite-porphyry, Copper Creek Basin. Contains augite, biotite, orthoclase, a little hornblende, and quartz.

D. Gabbro, southwest of Beams Hill, Sunlight Valley. Contains plagioclase, pyroxene, magnetite, apatite, and a little biotite.

	A.	B.	C.	D.
SiO_2	63.07	66.64	64.40	53.57
Al_2O_3	17.47	16.22	16.90	17.78
Fe_2O_3	2.09	1.84	1.86	3.19
FeO	1.38	1.06	1.37	4.93
MgO	1.44	1.25	1.13	4.36
CaO	2.27	2.41	2.60	6.22
Na_2O	5.77	5.11	5.79	4.04
K_2O	4.59	3.86	4.56	3.04
H_2O at 110°	.25	.52	.16	.27
H_2O above 110°	.43	.55	.39	.80
TiO_2	.38	.29	.23	.89
P_2O_5	.18	.16	.21	.44
ZrO_2	trace	.01	.02	....
Cr_2O_3	trace	trace	?	none
V_2O_3	trace	.01	?	....
NiO	none	none	none	none
MnO	.03	trace	.07	.07
SrO	.15	.14	.14	.13
BaO	.32	.27	.27	.21
Li_2O	trace?	none	trace	trace
CO_2	none	none	none	none
FeS_2	.02	trace?	trace?	....
	99.84	100.34	100.10	99.94

3D. ISHAWOOA INTRUSIVES.

Descriptions, hitherto unpublished, supplied by Arnold Hague and T. A. Jaggar, jr. Analyses A and B by H. N. Stokes, record No. 1804; C and D by W. F. Hillebrand, No. 1765.

A. Granite-porphyry, base of Crater Mountain. Contains oligoclase, orthoclase, biotite, and quartz.

B. Diorite-porphyry, Cabin Creek. Contains plagioclase, orthoclase, quartz, and abundant hornblende. This rock is intermediate between granite-porphyry and diorite-porphyry, but nearer to the latter.

C. Diorite, base of Needle Mountain. Contains plagioclase, quartz, biotite, with subordinate hornblende and orthoclase. Structure granitic.

D. Diabase, entrance to Shoshone Canyon. Contains plagioclase, augite, and chlorite.

	A.	B.	C.	D.
SiO_2	64.23	60.00	63.76	52.18
Al_2O_3	16.34	16.37	16.01	18.19
Fe_2O_3	1.07	2.28	2.22	3.31
FeO	1.58	2.46	1.96	4.36
MgO	2.47	3.81	2.43	4.69
CaO	3.07	4.96	4.55	6.51
Na_2O	3.49	3.73	3.98	4.58
K_2O	2.59	2.70	2.84	1.88
H_2O at 110°	.47	.61	.28	.75
H_2O above 110°	1.76	1.42	.57	2.00
TiO_2	.50	.59	.52	.99
P_2O_5	.18	.35	.25	.29
NiO	none	none	none	trace
MnO	trace	.05	.09	.14
SrO	.06	.11	.09	.06
BaO	.19	.26	.17	.11
Li_2O	trace	trace	trace	trace
CO_2	.30	.17	.23	none
Cl			trace	trace
S			(?)	none
FeS_2	1.61			
	99.91	99.87	99.95	100.04

4. DIKES IN BRECCIA.

Descriptions, hitherto unpublished, supplied by Arnold Hague and T. A. Jaggar, jr. Analyses A, B, D, by H. N. Stokes, record No. 1804; C, E, F, G, H, by W. F. Hillebrand, Nos. 1765 and 1801.

A. Hornblende-pyroxene-andesite, Eagle Creek. Contains plagioclase, hornblende, pyroxene, quartz, and apatite.

B. Leucite-absarokite, Sunlight Valley. Contains phenocrysts of olivine and augite, with secondary alteration of the olivine to serpentine. The groundmass contains magnetite, augite, plagioclase, and orthoclase. Leucite abundant.

C. Gabbro-porphyry, Deer Creek. Contains plagioclase, pyroxene, olivine, ilmenite, and apatite.

D. Hornblende-augite-andesite, Wind River Plateau. Contains phenocrysts of augite, hypersthene, and hornblende, plagioclase, and fine magnetite grains.

	A.	B.	C.	D.
SiO_2	50.72	47.32	50.29	60.15
Al_2O_3	16.01	11.22	15.85	17.85
Fe_2O_3	4.35	2.91	8.22	2.00
FeO	4.20	5.81	1.43	2.02
MgO	7.06	15.96	4.65	3.26
CaO	9.02	7.11	7.71	5.48
Na_2O	2.92	1.88	2.98	3.95
K_2O	1.13	3.79	3.53	2.36
H_2O at 110°	.40	.31	1.77	.25
H_2O above 110°	2.14	1.71	1.98	1.24
TiO_2	1.08	.75	.96	.47
P_2O_5	.29	.61	.51	.22
ZrO_2	....	....	....	....
Cr_2O_3	none	trace	....	none
V_2O_3	....	....	....	....
NiO	none	trace	trace	none
MnO	.07	.11	.15	.07
SrO	.09	.05	.09	.10
BaO	.11	.22	.15	.20
Li_2O	trace	trace	trace	none
CO_2	.85	.13	none	none
Cl	....	....	trace	....
FeS_2	....	....	....	....
	100.44	99.89	100.27	99.62

E. Augite-andesite, Dike Mountain. Contains augite, plagioclase, serpentinized olivine, magnetite, and apatite.

F. Trachyte-andesite, Dike Mountain. Contains plagioclase, orthoclase, chlorite, apatite, and magnetite. Very little augite.

G. Biotite-trachyte, Dike Mountain. Contains plagioclase, orthoclase, biotite, magnetite, and chlorite.

H. Biotite-trachyte, Dike Mountain. Contains orthoclase, plagioclase, biotite, and magnetite.

	E.	F.	G.	H.
SiO_2	51.17	52.47	63.24	57.73
Al_2O_3	16.14	18.23	17.98	18.93
Fe_2O_3	4.11	3.31	2.67	1.97
FeO	4.48	3.85	.85	1.92
MgO	4.82	2.85	.63	.91
CaO	7.72	4.56	.93	2.78
Na_2O	2.99	4.83	6.27	5.52
K_2O	3.54	3.81	5.47	6.11
H_2O at 110°	.63	.68	.37	.22
H_2O above 110°	2.24	2.03	.80	2.93
TiO_2	1.01	.97	.38	.33
P_2O_5	.48	.64	.22	.25
ZrO_2	none	.02	trace	trace
Cr_2O_3	trace	trace	none	trace
V_2O_3	.04	.03	.01	.01
NiO	.01	trace	none	trace ?
MnO	.21	.15	.04	.06
SrO	.10	.11	.03	.09
BaO	.20	.23	.25	.16
Li_2O	trace	trace	trace	trace
CO_2	none	1.01	none	.26
FeS_2	.05	.04	trace	.02
	99.94	99.82	100.14	100.20

4. ABSAROKITE—SHOSHONITE—BANAKITE SERIES.

Rocks from the Yellowstone Park and the Absaroka Range, described in Mon. XXXII, Pt. II, and also by Iddings in Journal of Geology, vol. 3, pp. 938, 943, 947. The rock A, from Ishawooa Canyon, is also described by Hague in Amer. Journ. Sci., 3d series, vol. 38, p. 46.

A. Leucite-absarokite, Ishawooa Canyon, Wyoming. Bowlder. Contains olivine and augite in a groundmass of orthoclase and leucite. Accessory minerals, magnetite, apatite, and a few flakes of brown mica. Analysis by J. E. Whitfield, record No. 1057. Material dried at 104°.

B. Absarokite dike, head of Lamar River. Contains olivine and augite in a groundmass of orthoclase and plagioclase, with accessory magnetite, biotite, and ilmenite.

C. Absarokite dike, south of Clark Fork. Contains augite, quartz, biotite, magnetite, orthoclase, plagioclase, and sometimes analcite.

D. Absarokite lava flow, head of Raven Creek. Contains olivine, augite, orthoclase, labradorite, magnetite, apatite, and a little serpentine.

E. Absarokite dike, divide east of Cache Creek. Contains orthoclase, plagioclase, augite, biotite, magnetite, serpentine, and occasional quartz.

Analyses B, C, D, and E by L. G. Eakins, record Nos. 1086, 1365.

	A.	B.	C.	D.	E.
SiO_2	47.28	48.95	48.36	51.76	49.71
Al_2O_3	11.56	12.98	12.42	12.36	13.30
Fe_2O_3	3.52	3.63	5.25	4.88	4.41
FeO	5.71	4.68	2.48	4.60	3.37
MgO	13.17	11.73	9.36	9.57	7.96
CaO	9.20	7.66	8.65	7.14	8.03
Na_2O	2.73	2.31	1.46	1.99	1.49
K_2O	2.17	3.96	3.97	3.83	4.81
H_2O	2.96	3.16	5.54	3.05	4.07
TiO_2	.88	.49	1.18	.47	1.57
P_2O_5	.59	.67	.84	.56	.66
Cr_2O_3			trace		trace
MnO	.13	.13	.13	.11	.17
BaO			.29		.46
Cl	.18				
	100.08	100.35	99.93	100.32	100.01
O=Cl	.04				
	100.04				

F. Shoshonite lava sheet, Lamar River, south of Bison Peak. Contains plagioclase, orthoclase, augite, olivine, magnetite, and serpentine, with amygdules of zeolite and calcite. Analysis by Eakins, No. 1086.

G. Shoshonite lava sheet, southeast fork of Beaverdam Creek. Contains plagioclase, orthoclase, augite, and serpentinized olivine.

H. Leucite (?) shoshonite lava sheet, mountain east of Pyramid Peak. Contains feldspars, olivine, serpentine, augite, magnetite, brown mica, and impure leucite (?).

I. Olivine-free shoshonite dike, northeast of Indian Peak. Contains augite, plagioclase, biotite, and magnetite.

J. Shoshonite lava sheet, Two Ocean Pass. Contains orthoclase, serpentinized olivine, magnetite, augite, chlorite, biotite, apatite, labradorite. Dried at 104°.

Analyses G, H, I by Eakins, Nos. 1371, 1375, 1379. Analysis J by Whitfield, No. 906.

	F.	G.	H.	I.	J.
SiO_2	50.06	53.49	52.49	54.86	56.05
Al_2O_3	17.00	17.19	17.89	17.28	19.70
Fe_2O_3	2.96	4.73	5.76	4.08	3.74
FeO	5.42	3.25	2.08	2.28	2.32
MgO	3.61	4.42	3.49	4.19	2.51
CaO	8.14	6.34	7.01	5.42	4.34
Na_2O	3.53	3.23	3.18	3.94	3.29
K_2O	3.40	3.86	3.73	3.96	4.44
H_2O	4.85	2.17	2.63	2.16	1.86
TiO_2	.51	.71	.81	.69	.98
P_2O_5	.66	.43	.55	.48	.66
MnO	.14	.14	.09	.19	trace
BaO		.06	.30	.37	
Li_2O					.06
SO_3					.19
	100.28	100.02	100.01	99.90	100.14

K. Banakite dike, head of Lamar River. Contains augite, serpentinized olivine, orthoclase, plagioclase, biotite, magnetite, ilmenite, apatite, and analcite. Adjoins rock B. Analyses by Eakins, No. 1375.

L. Banakite dike, Hoodoo Mountain. Like K, but with amygdaloidal zeolites. Analysis by Eakins, No. 1371.

M. Banakite dike, Ishawooa Canyon, Wyoming. Like K and L, but more feldspathic. Contains a little serpentine, probably from olivine; also possibly analcite or sodalite. Analysis by Eakins, No. 1086.

N. Banakite dike, near head of Stinkingwater River. Like M, but with more serpentine. Analysis by W. H. Melville, record No. 1232.

	K.	L.	M.	N.
SiO_2	51.82	52.63	51.46	52.33
Al_2O_3	16.75	16.87	18.32	18.70
Fe_2O_3	4.56	4.52	4.61	4.95
FeO	3.36	3.11	2.71	1.83
MgO	4.03	3.69	2.91	2.69
CaO	4.94	4.77	6.03	4.71
Na_2O	3.91	3.86	4.11	4.51
K_2O	5.02	5.17	4.48	5.45
H_2O at 100°	3.97	3.65	3.89	.74
H_2O above 100°				2.71
TiO_2	.71	.81	.83	.71
P_2O_5	.52	.63	.86	.81
MnO	.23	.10	.17	.03
NiO	....	....	....	.14
BaO	.26	.29	....	....
	100.08	100.10	100.38	100.31

O. Leucite-banakite lava sheet, southeast fork of Beaverdam Creek. Overlies rock G. Contains olivine, augite, leucite, feldspars, magnetite, apatite, and a little brown mica. Analysis by Eakins, No. 1378.

P. Earlier unpublished analysis of O, another sample, by J. E. Whitfield, record No. 907.

Q. Quartz-banakite dike, near head of Stinkingwater River. Contains plagioclase, orthoclase, quartz, biotite, magnetite, augite, and a little calcite. Analysis by Melville, No. 1232.

R. Quartz-banakite dike, near Q. Contains plagioclase, orthoclase, quartz, biotite, magnetite, augite, chlorite, and serpentine. Analysis by Melville, No. 1232.

	O.	P.	Q.	R.
SiO_2	52.93	51.56	57.29	60.89
Al_2O_3	19.67	21.00	18.45	17.14
Fe_2O_3	3.07	5.17	4.38	3.32
FeO	3.50	2.76	1.20	.95
MgO	2.88	2.52	2.08	1.16
CaO	4.69	4.83	3.57	3.58
Na_2O	4.20	4.37	4.43	4.54
K_2O	4.75	4.13	5.43	5.71
H_2O at 100°	2.73	2.27	.17	.39
H_2O above 100°			2.01	1.22
TiO_2	.72	.65	.72	.49
P_2O_5	.59	.69	.46	.27
MnO	.15	trace	trace	.09
NiO			.12	.19
BaO	.21			
Li_2O		.13		
SO_3		.21		
Cl		trace		
	100.09	100.29	100.31	99.94

S. Absarokite, Two Ocean Pass. Contains augite, olivine, orthoclase, magnetite, serpentine, little biotite, apatite, and an isotropic substance, probably glass. Analysis by J. E. Whitfield, record No. 906,

T. Shoshonite, Beaverdam Creek. Analysis by Whitfield, No. 907. Probably the rock already represented by analysis G.

U. Shoshonite, northeast spur of Sepulchre Mountain. Contains augite and serpentinized olivine, in a groundmass of plagioclase, orthoclase, augite, magnetite, and apatite. Analysis by Whitfield, No. 908.

V. Shoshonite, Baldy Mountain, Bear Gulch, Montana. Contains hypersthene, augite, olivine, plagioclase, orthoclase, and magnetite. Analysis by Whitfield, No. 909.

	S.	T.	U.	V.
SiO_2	51.68	52.86	51.75	54.97
Al_2O_3	14.07	17.51	17.48	18.38
Fe_2O_3	4.71	5.18	6.42	3.06
FeO	4.57	3.31	1.46	4.22
MgO	7.72	4.18	4.05	2.38
CaO	6.65	6.51	8.20	5.43
Na_2O	2.45	3.22	3.33	3.45
K_2O	4.16	3.41	3.72	3.37
H_2O	2.09	1.76	2.26	.82
TiO_2	1.08	1.04	.86	.97
P_2O_5	.72	.53	.67	.42
MnO	trace	trace	trace	trace
Li_2O	trace	.04	trace	.03
SO_3	.13	.22	.17	.03
Cl	....	.16	trace	trace
CO_2	....	....	....	2.92
	100.03	99.93	100.37	100.45

5. MISCELLANEOUS ROCKS. FIRST GROUP.

Collected and investigated by Arnold Hague and J. P. Iddings.

A. Black obsidian, Obsidian Cliff. Described by Iddings, 7th Ann. Contains microlites of augite and magnetite, with traces of quartz and feldspar. Analysis by J. E. Whitfield, record No. 224.

B. Red obsidian, Obsidian Cliff. Described by Iddings, 7th Ann. Like A, with ferric oxide replacing magnetite. Analysis by Whitfield, No. 223.

C. Obsidian, east of Willow Park. Black and opaque. Described by Iddings, Bull. Phil. Soc. Washington, vol. 12, p. 204. Analysis by Whitfield, No. 222.

D. Lithoidite, Obsidian Cliff. Described by Iddings, Bull. 150, p. 153. Contains quartz and sanidine, with a little magnetite and augite. Analysis by Whitfield, No. 425.

E. Rhyolite, Upper Geyser Basin. See Iddings, Bull. Phil. Soc. Washington, vol. 12, p. 204. Analysis by F. A. Gooch, record No. 114.

F. Rhyolite, Tower Creek. See Iddings, Bull. Phil. Soc. Washington, vol. 12, p. 204. Analysis by Gooch, No. 115.

	A.	B.	C.	D.	E.	F.
SiO_2	74.70	75.52	72.59	75.50	70.92	71.85
Al_2O_3	13.72	14.11	13.47	13.25	13.24	13.17
Fe_2O_3	1.01	1.74	1.58	1.02	3.54	2.17
FeO	.62	.08	1.32	.91	.66	1.34
MgO	.14	.10	1.05	.07	.23	.63
CaO	.78	.78	2.12	.90	1.42	2.25
Na_2O	3.90	3.92	4.63	4.76	4.28	4.06
K_2O	4.02	3.63	2.52	2.85	4.25	3.89
H_2O	.62	.39	.18	.41	.57	.43
TiO_2	none	none	.52	none	.16	.43
P_2O_5	none			none	.18	.14
MnO	trace	none	none	none	.14	.12
Li_2O				.06	none	
SO_3				.32		
FeS_2	.40	.11	.26			
	99.91	100.38	100.24	100.05	100.59	100.48

G. Rhyolite, "Great Paint Pots." Analysis by Gooch, No. 113, hitherto unpublished.

H. Rhyolite, "Elephants Back." Porphyritic obsidian. Analysis by Whitfield, No. 423, hitherto unpublished. Reported by Iddings as containing quartz, sanidine, and a little augite and magnetite, in a glassy, microlitic groundmass.

I. Rhyolite, Mount Sheridan. Composition reported by Iddings as quartz and sanidine, with a little magnetite and augite. Analysis by Whitfield, No. 426, hitherto unpublished.

J. Rhyolite, Madison Plateau. Like I. Analysis by Whitfield, No. 427, not yet published.

K. Trachytic rhyolite, Elk Creek. Analysis by Whitfield, No. 428, hitherto unpublished. Reported by Iddings as containing sanidine, labradorite, and little biotite, in a groundmass of quartz and alkali feldspar

	G.	H.	I.	J.	K.
SiO_2	75.71	75.34	75.89	75.19	64.65
Al_2O_3	11.11	12.51	12.27	13.77	17.80
Fe_2O_3	1.56	.42	1.12	.61	2.33
FeO	.37	1.55	1.37	1.37	2.10
MgO	.08	.32	.29	.09	.81
CaO	.88	1.07	.86	.68	1.73
Na_2O	4.64	3.31	3.23	3.83	4.18
K_2O	4.18	4.17	3.42	3.33	2.83
H_2O	.35	.86	.82	.65	3.06
TiO_2	1.25	none	.50	none	trace
P_2O_5	....	none	none	none	trace
MnO	.07	.07	none	trace	trace
Li_2O	....	trace	.01	.02	.17
SO_3	....	.42	.28	.29	.43
	100.20	100.04	100.06	99.83	100.09

L. Trachytic rhyolite-tuff, Two Ocean Pass. Analysis by Whitfield, No. 906, hitherto unpublished. Reported by Iddings as containing sanidine, labradorite, biotite, magnetite, and augite, in a somewhat altered, glassy groundmass. Also contains fragments of andesite.

M. Glassy trachyte, approaching rhyolite, Sunset Peak, Bear Gulch. Contains phenocrysts of sanidine, plagioclase, and biotite. See Iddings, Bull. Phil. Soc. Washington, vol. 12, p. 205; also Mon. XXXII, Pt. II. Analysis by L. G. Eakins, record No. 1378.

N. Altered rhyolite, "Iron Pot," Lower Basin. Collected by W. H. Weed. Analysis by Whitfield, No. 546, hitherto unpublished.

O. Dacite-porphyry, Echo Peak.

P. Same as O, Mount Holmes. Analyses O and P by Whitfield, Nos. 421, 422, hitherto unpublished. Reported by Iddings as containing plagioclase, probably oligoclase, quartz, little biotite, and magnetite.

	L.	M.	N.	O.	P.
SiO_2	61.15	69.45	89.20	74.51	69.54
Al_2O_3	15.70	14.92	2.39	14.83	17.95
Fe_2O_3	4.31	3.16	1.21	1.09	2.50
FeO	1.12	.23	none	trace	.22
MgO	3.04	.05	trace	.47	.50
CaO	2.84	1.19	trace	.81	1.80
Na_2O	1.54	3.19	1.11	4.38	4.30
K_2O	2.22	5.95	.79	2.72	1.21
H_2O	7.05	1.69	5.09	.92	1.96
TiO_2	.69	.19	none	none	none
P_2O_5	.75	.06	none	trace	none
MnO	trace	.07	....	none	none
BaO	....	.03	....	....	....
Li_2O	none	....	....	.02	trace
SO_3	.18	....	.44	.24	.37
	100.59	100.18	100.23	99.99	100.35

Q. Mica-dacite-porphyry, Bunsen Peak. Analysis by Whitfield, No. 419, hitherto unpublished. Reported by Iddings as containing oligoclase-andesine, quartz, biotite, little magnetite, apatite, and zircon.

R. Mica-dacite-porphyry, Birch Hills. Like Q in composition. Analysis by Whitfield, No. 718, hitherto unpublished.

S. Hornblende-mica-andesite-porphyry, Fan Creek. Analysis by Whitfield, No. 713, hitherto unpublished. Reported by Iddings as containing andesine-oligoclase, hornblende, and biotite, in a groundmass of feldspar (probably oligoclase and orthoclase), with a little magnetite, biotite, and hornblende.

T. Hornblende-mica-andesite-porphyry, Gray Peak. Analysis by Whitfield, No. 715, hitherto unpublished. Composition similar to that of S.

	Q.	R.	T.	S.
SiO_2	70.52	70.24	65.63	65.64
Al_2O_3	15.85	17.36	17.00	17.29
Fe_2O_3	2.28	1.38	2.55	3.07
FeO	.36	.79	1.19	1.29
MgO	.09	.53	2.03	1.78
CaO	2.59	2.74	3.48	1.98
Na_2O	3.93	3.69	4.42	5.77
K_2O	3.43	2.65	1.64	2.44
H_2O	.35	.71	2.00	1.03
TiO_2	trace	trace	trace	none
P_2O_5	.17	trace	.07	.23
MnO	.09	none	none	trace
Li_2O	trace	none	.04	.04
SO_3	.29	trace	trace	trace
Cl	....	none	trace	trace
CO_2	....	none	.27	.17
	99.95	100.09	100.32	100.73

U. Hornblende-mica-andesite, Crescent Hill. Analysis by Whitfield, No. 432, hitherto unpublished. Reported by Iddings as containing oligoclase-andesine, biotite, and subordinate decomposed hornblende, in a groundmass of feldspar and quartz, with a little magnetite and biotite.

V. Hornblende-andesite, Tower Creek. Analysis by Gooch, No. 117, hitherto unpublished. Reported by Iddings as containing plagioclase, hornblende, and a little augite.

W. Pyroxene-andesite, Agate Creek. Analysis by Whitfield, No. 432, hitherto unpublished. Reported by Iddings as containing augite, hypersthene, labradorite, and magnetite, in a glassy, microlitic groundmass.

X. Rhyolitic perlite, described by Iddings, Bull. 150, p. 153. Analysis by H. N. Stokes, No. 1314, hitherto unpublished. From a bluff opposite the Midway Geyser Basin. Reported by Iddings as containing quartz, sanidine, plagioclase, and rarely augite and magnetite, with microscopic zircon and apatite, in a glassy groundmass. P. R. C. 61.

	U.	V.	W.	X.
SiO_2	64.61	61.56	61.45	73.84
Al_2O_3	18.62	14.73	15.07	12.47
Fe_2O_3	2.78	4.47	4.46	.32
FeO	.95	1.23	1.18	.90
MgO	.85	3.57	3.02	.25
CaO	4.20	4.87	5.37	1.08
Na_2O	4.37	5.10	4.00	2.88
K_2O	2.36	2.24	1.22	5.38
H_2O	.93	1.42	1.23	2.76
TiO_2	none	.87	2.80	....
P_2O_5	.30	.04	trace	....
MnO	trace	.34	none	trace
Li_2O	.01	....	.05	....
SO_3	trace	....	.29	....
Cl	trace	....	....	....
CO_2	.25	....	....	....
	100.23	100.44	100.14	99.88

MISCELLANEOUS ROCKS. SECOND GROUP.

Collected and investigated by Arnold Hague and J. P. Iddings.

A. Pyroxene-andesite, west of Dunraven Peak. Analysis by F. A. Gooch, record No. 116, hitherto unpublished. Reported by Iddings as containing labradorite, augite, hypersthene, and magnetite, in a microlitic groundmass.

B. Basalt, southwest of Dunraven Peak. Analysis by Gooch, No. 118, hitherto unpublished. Reported by Iddings as containing augite, olivine, labradorite-bytownite, and magnetite, in a globulitic glassy groundmass.

C. Basalt, north spur of Prospect Peak. Analysis by J. E. Whitfield, record No. 431, hitherto unpublished. Reported by Iddings as containing labradorite, augite, olivine, and magnetite. Little glass in groundmass.

D. Basalt, Yellowstone Canyon. Analysis by Whitfield, No. 430, hitherto unpublished. Reported by Iddings as containing labradorite-bytownite, augite, olivine, magnetite, and a little brown glass.

E. Basalt, Stinkingwater Canyon. See Iddings, Bull. Phil. Soc. Washington, vol. 12, p. 205. Analysis by W. H. Melville, record No. 1232.

	A.	B.	C.	D.	E.
SiO_2	56.47	51.70	47.17	51.70	52.37
Al_2O_3	15.33	15.18	17.85	17.90	16.57
Fe_2O_3	2.54	2.09	7.42	7.24	6.34
FeO	4.53	8.54	1.18	1.00	2.35
MgO	5.08	8.18	6.54	2.77	5.27
CaO	6.93	8.73	10.12	6.94	8.54
Na_2O	3.81	2.31	2.94	4.17	2.99
K_2O	1.66	1.81	.56	1.62	2.45
H_2O at 100°	1.65	.16	.65	1.15	1.18
H_2O above 100°					1.04
TiO_2	.99	1.24	2.13	3.17	.73
P_2O_5	.54	.21	.20	.41	.31
Fe, metal	....	....	3.26	1.81	....
MnO	.18	trace	none	trace	.07
NiO	....	....	....	....	.12
Li_2O	....	....	.02	.03	....
SO_3	....	....	.51	.32	....
S	....	.09	....	....	....
Cl	....	trace	....	....	....
	99.71	100.24	100.55	100.23	100.33

F. Camptonite (?), dike in Stinkingwater Canyon. See Iddings, Bull. Phil. Soc. Washington, vol. 12, p. 205. Analysis by Melville, No. 1232.

G. Kersantite, Bighorn Pass. Described by Iddings in Mon. XXXII, Pt. II. Contains hornblende, plagioclase, orthoclase, quartz, augite, biotite, magnetite, chlorite, calcite, and apatite. Augite and hornblende partly decomposed. Analysis by Whitfield, No. 714.

H. Basalt, dike, north spur of Mount Washburn. Analysis by Whitfield, No. 717, hitherto unpublished. Reported by Iddings as approaching pyroxene-andesite in composition. Contains labradorite, augite, serpentinized olivine, and magnetite, in a groundmass of globulitic and microlitic brown glass.

	F.	G.	H.
SiO_2	50.99	48.73	53.75
Al_2O_3	15.62	11.92	20.75
Fe_2O_3	8.47	4.79	4.50
FeO	1.43	4.56	3.53
MgO	5.23	5.93	3.76
CaO	6.53	9.24	7.18
Na_2O	3.39	2.62	4.16
K_2O	3.05	2.47	1.37
H_2O at 100°	1.39	1.52	1.55
H_2O above 100°	2.48		
TiO_2	.67	1.34	none
P_2O_5	.53	.32	.15
MnO	trace	.36	trace
NiO	.07	....	....
BaO	....	trace	....
Li_2O	....	trace	trace
SO_3	....	.34	trace
Cl	....	.11	none
CO_2	....	5.80	none
	99.85	100.05	100.70

MONTANA.

1. MADISON AND GALLATIN VALLEYS.

Rocks collected by A. C. Peale and G. P. Merrill. Described by Merrill in Proc. U. S. National Museum, vol. 17, p. 637. See also Bull. 110, p. 47.

A. Basalt?, east side of Bozeman Creek, 2½ miles southeast of Bozeman. Contains olivine and augite, chloritized and serpentinized. The colorless groundmass contains apparently two feldspars and a pyroxene, with grains of iron oxide. Analysis by T. M. Chatard, record No. 517. Sp. gr. 2.86. P. R. C. 971.

B. Pyroxene from A. Analysis by L. G. Eakins, record No. 1046.

C. Portion of A soluble in hydrochloric acid. Contains olivine, iron oxides, and decomposition products. Analysis by Eakins, record No. 817.

	A.	B.	C.
SiO_2	46.90	52.50	20.88
Al_2O_3	10.17	2.26	3.89
Fe_2O_3	1.22	2.05	2.21
FeO	5.17	2.47	4.28
MgO	20.98	17.11	16.44
CaO	6.20	21.70	1.01
Na_2O	1.16	.35	trace
K_2O	2.04	.07	trace
H_2O at 120°	1.04	.64	
H_2O above 120°	4.38		....
TiO_2	.41	....	....
P_2O_5	.44	....	....
Cr_2O_3	.33	1.07	....
MnO	.10	trace	trace
	100.54	100.32	48.71

D. Highly altered porphyrite?, hills 1 mile north of East Gallatin River, near camp No. 6. Rock contains hornblende paramorphs after augite in a devitrified base, with amygdules of calcite, chloritic and ferruginous matter derived from porphyritic augite and olivine. The base is also filled with needles, which may be mica. Analysis by Eakins, record No. 820. P. R. C. 968.

E. Lamprophyre, Cottonwood Creek. Contains porphyritic augite and olivine in an indeterminate groundmass carrying augite, iron oxides, and mica. Analysis by Chatard, record No. 516. P. R. C. 979.

F. Augite-porphyry, Cottonwood Creek. Contains feldspars, augite, and brown mica, with iron oxides, apatite, glass, and secondary calcite and chlorite. Carries porphyritic plagioclase and augite. No unaltered olivine visible. Sp. gr. 2.785. Analysis by Eakins, record No. 819. P. R. C. 965.

	D.	E.	F.
SiO_2	49.47	51.65	52.33
Al_2O_3	12.15	13.89	15.09
Fe_2O_3	1.93	2.70	4.31
FeO	4.07	4.80	4.03
MgO	10.86	11.56	6.73
CaO	9.30	4.07	7.06
Na_2O	2.08	2.99	3.14
K_2O	2.42	4.15	3.76
H_2O at 120°	4.14	1.30	2.68
H_2O above 120°		1.89	
TiO_2	.21	.55	.14
P_2O_5	.37	.21	1.02
Cr_2O_3	trace	.08	....
MnO	.10	.15	.09
BaO	.03	.19	.07
SO_3	....	.19	....
CO_2	3.31	....	....
	100.44	100.37	100.45

G. Basalt?, Bear Creek. Resembles A, but with a more crystalline groundmass. Contains plagioclase, possibly sanidine, augite, olivine, and iron oxides. Analysis by Chatard, record No. 1154. P. R. C. 967.

H. Lamprophyre, between South Boulder and Antelope creeks. Contains porphyritic augite and olivine in a feldspathic groundmass, with apatite, augite, grains of iron oxide, and shreds of brown mica. Sp. gr. 2.96. Analysis by Eakins, record No. 1266. P. R. C. 966.

I. Lamprophyre, hills east of South Boulder Creek. Nodules from a decomposed mass. Shows sanidine, plagioclase, brown mica, and altered olivine.

	G.	H.	I.
SiO_2	49.13	50.82	50.03
Al_2O_3	9.05	11.44	14.08
Fe_2O_3	3.57	.25	2.92
FeO	5.05	8.94	6.11
MgO	17.21	14.01	10.73
CaO	5.68	8.14	7.46
Na_2O	2.01	1.79	1.46
K_2O	2.24	3.45	2.64
H_2O at 110°	.84	.58	3.70
H_2O above 110°	3.50		
TiO_2	.42	.59	.61
P_2O_5	.38	.20	.42
Cr_2O_3	.39	.03	trace
NiO	trace	trace	trace
MnO	.15	.19	.08
BaO	.05	.06	.04
	99.67	100.49	100.28

J. Hornblende-picrite, North Meadow Creek. Contains hornblende, abundant fresh olivine, grains of pleonaste and iron oxides, and occasionally hypersthene. Sp. gr. 3.35. P. R. C. 973.

K. Pyroxenite, divide between Meadow and Granite creeks. Contains hornblende and hypersthene, with grains of iron oxide. P. R. C. 972.

L. Hypersthene-andesite, northwest of Red Bluff. Contains plagioclase and pyroxene, with an amorphous glassy base, and sometimes olivine altered to chloritic matter.

M. Peridotite, var. wehrlite, hills 3 miles northwest of Red Bluff. Contains olivine, diallage, brown mica, rarely plagioclase, and secondary iron oxides. Sp. gr. 3.37. Analyses J, K, L, and M by Eakins, record No. 1266. P. R. C. 976.

	J.	K.	L.	M.
SiO_2	46.13	51.83	59.48	48.95
Al_2O_3	4.69	7.98	16.37	5.69
Fe_2O_3	.73	1.48	3.21	1.20
FeO	16.87	8.28	3.17	12.11
MgO	25.17	24.10	3.29	23.49
CaO	4.41	5.26	4.88	5.33
Na_2O	.08	.35	3.30	1.58
K_2O	trace	.06	2.81	.79
H_2O	1.38	.29	2.01	.18
TiO_2	.73	.29	.93	.81
P_2O_5	.07	.09	.41	.12
Cr_2O_3	.04	.31	.03	.05
MnO	trace	trace	.19	.08
NiO	.09	.11	trace	.16
BaO	trace	....	.13	trace
S	.24	....	....	....
	100.63	100.43	100.21	100.54
Less O	.12			
	100.51			

The following rocks, at first supposed to be Pliocene sandstones, were also described by Merrill, Amer. Journ. Sci., 3d series, vol. 32, p. 119. All consist of pumiceous volcanic glass. C, from Idaho, is included here for convenience. Analyses by J. E. Whitfield, record No. 382.

A. Little Sage Creek.
B. Devils Pathway.
C. Marsh Creek Valley, Idaho.

Iron and alumina weighed together. The iron is mostly in the ferrous form.

	A.	B.	C.
SiO_2	65.56	65.76	68.92
Al_2O_3, Fe_2O_3	18.24	17.18	16.22
MgO	.72	trace	trace
CaO	2.58	2.30	1.62
Na_2O	2.08	2.22	1.56
K_2O	3.94	3.14	4.00
H_2O at 105°	1.12	3.46	1.60
H_2O at red heat	6.50	5.60	6.00
	100.74	99.66	99.92

The following examples of volcanic dust or sand, from the Gallatin Valley, were collected by A. C. Peale. Analyses A, B, C, and D by F. W. Clarke, record No. 379. Analysis E by H. N. Stokes, record No. 1314.

A. Dry Creek Valley, above the mouth of Pass Creek.
B, C. Near Bozeman.
D. Near Fort Ellis.
E. Essentially rhyolitic glass, described by Iddings in Bull. 150, p. 146. Gallatin Valley.

	A.	B.	C.	D.	E.
SiO_2	46.09	61.82	71.01	60.98	68.68
Al_2O_3	14.35	19.86	15.17	21.69	12.69
Fe_2O_3					1.14
FeO	....	....	....	....	1.17
MgO	1.29	.51	.34	1.33	1.14
CaO	1.61	1.78	1.19	1.83	1.11
Na_2O	1.47	2.38	2.77	.80	1.23
K_2O		1.31	2.97	1.23	5.58
Ignition	6.45	11.47	6.34	11.96	7.99
MnO_2	....	....	....	....	trace
$CaCO_3$	28.72	....	....	....	....
	99.98	99.13	99.79	99.82	100.73

2. BUTTE AND BOULDER DISTRICTS.

Rocks received from W. H. Weed and G. W. Tower. The granite rocks are described by Weed in Journ. Geol., vol. 7, p. 737. All the rocks will be described in the 21st Annual Report.

A. Butte granite. A quartz-monzonite, variety banatite, from Walkerville Station. Contains quartz, andesine, orthoclase, hornblende, and biotite, with a little titanite, apatite, and magnetite.

B. Biotite from A.

C. Amphibole from A.

D. Butte granite, like A, from the Frohner mine, 10 miles south of Helena.

Analyses by H. N. Stokes, record Nos. 1686, 1787, 1808.

	A.	B.	C.	D.
SiO_2	63.88	35.79	45.73	64.17
Al_2O_3	15.84	13.70	6.77	15.25
Fe_2O_3	2.11	5.22	4.94	2.16
FeO	2.59	13.72	10.39	2.98
MgO	2.13	12.13	12.32	2.60
CaO	3.97	.05	11.25	4.24
Na_2O	2.81	.15	.77	2.62
K_2O	4.23	9.09	1.22	4.34
H_2O at 110°	.22	1.21	.49	.16
H_2O above 110°	.66	3.64	2.29	.65
TiO_2	.65	3.51	1.43	.67
P_2O_5	.21	.10	.35	.16
MnO	.07	.19	.54	.04
SrO	.02	none	none	trace
BaO	.09	.13	none	.07
Li_2O	trace	trace	trace	trace
SO_3	.34	....	....	.07
Cl	trace	.20	....	trace
F	....	.76	.28	....
	99.82	99.59	98.77	100.18
Less O	....	.37	.12	
		99.22	98.65	

E. Butte granite, Gagnon mine, Butte.

F. Butte granite, Atlantic mine, Butte.

G. Butte granite, Alice mine, Butte. Analyses E, F, and G by V. H. Hillebrand, record No. 1692. Mineralogically the rocks are ke A and D.

H. Weathered Butte granite.

I. Altered Butte granite. Decomposed near quartz-pyrite veins. hows opaline silica, with sericite derived from feldspar. Hornblende one; mica recognizable only as sericite masses having the form of iotite.

Analyses H and I by Stokes, record Nos. 1792, 1787.

	E.	F.	G.	H.	I.
SiO_2	64.05	64.34	63.87	65.14	64.81
Al_2O_3	15.38	15.72	15.39	15.63	19.44
Fe_2O_3	2.20	1.62	1.93	2.37	1.82
FeO	2.74	2.94	3.08	2.13	.16
MgO	2.08	2.17	2.23	1.85	.19
CaO	4.30	4.24	4.30	3.62	.18
Na_2O	2.74	2.76	2.76	2.63	.21
K_2O	4.00	4.04	4.18	4.29	5.30
H_2O at 110°	.27	.25	.19	.37	1.41
H_2O above 110°	.83	.76	.69	.75	5.25
TiO_2	.60	.53	.65	.59	.73
P_2O_5	.21	.14	.17	.16	.10
ZrO_2	(?)	.02	.03	....	....
MnO	.11	.12	.11	trace	trace
NiO	trace ?	trace ?	trace	....	....
SrO	.04	.03	.04	trace	trace
BaO	.08	.06	.07	.10	.10
CO_2	.35	.03	.15	none	none
SO_3	....	....	....	.05	.31
FeS_2	.07	.03	.07	....	....
Cu	.005	.005	.005	....	....
	100.055	99.805	99.915	99.68	100.01

Traces of lithia in all five rocks of this table.

J. Granite, Boulder type, near Boulder. Near adamellite. Contains quartz, feldspar, black mica, and dark-green hornblende. Has an unusual amount of plagioclase.

K. Bluebird granite, Nettie mine, Butte district. An aplite. Contains orthoclase and quartz, with a little plagioclase and a sprinkling of biotite.

L. Same rock and locality as K. Analysis by W. F. Hillebrand, record No. 1692.

M. Diorite, Red Mountain, east of Butte. Contains pale-green to colorless hornblende, plagioclase varying from labradorite to albite, some orthoclase, and a little quartz. Biotite, apatite, and magnetite also occur.

N. Diorite, Red Mountain. Contact of granite with limestones. Consists mainly of green hornblende and "basic" plagioclase. Little quartz present.

O. Quartz-monzonite, Red Rock Creek, north of Butte. Contains hornblende, augite, biotite, plagioclase, and orthoclase, with a little magnetite and apatite.

Analyses J, K, M, N, and O by H. N. Stokes, record Nos. 1686, 1787.

	J.	K.	L.	M.	N.	O.
SiO_2	67.12	76.87	77.05	56.41	49.22	61.64
Al_2O_3	15.00	12.52	12.84	17.62	12.02	15.63
Fe_2O_3	1.62	.67	.56	1.24	2.77	3.39
FeO	2.23	none	.14	3.55	8.80	2.69
MgO	1.74	.09	trace	3.97	9.29	2.82
CaO	3.43	.49	.57	8.66	10.56	4.90
Na_2O	2.76	2.47	2.81	3.25	1.90	2.64
K_2O	4.52	5.78	5.52	2.61	1.70	3.72
H_2O at 110°	.09	.25	.22	.14	.27	.28
H_2O above 110°	.58	.52	.48	.76	1.63	.91
TiO_2	.48	.11	.12	.68	.95	.71
P_2O_5	.15	.05	none	.49	.43	.21
Cr_2O_3	none	....	....	....	....	trace
MnO	.06	trace	none	.08	trace	.04
SrO	.03	none	none	.08	.03	.04
BaO	.07	none	none	.09	.03	.08
Li_2O	trace	trace	trace	none	trace	trace
S	....	trace	....	none	.05	....
SO_3	trace		....	none	.04	none
Cl	....	none	....	.07	.08	....
	99.88	99.82	100.31	99.70	99.77	99.70

P. Pitchstone, or rhyolite-dacite obsidian, Butte. Phenocrysts of andesine, quartz, and orthoclase in a glassy base.

Q. Rhyolite, Hyde Park dike, Butte district. Contains sanidine, quartz, plagioclase, and biotite in a groundmass of quartz and feldspar.

R. Rhyolite, top of Red Mountain, Rimini. Quarts and feldspar phenocrysts in a groundmass of the same minerals.

S. Quartz-porphyry, Modoc mine, Butte district. Contains quartz, orthoclase, and plagioclase in a groundmass of quartz and feldspar. A few small biotites are present. Feldspar partly altered to sericite.

T. Andesite-porphyry, Hiawatha Creek, above basin. Contains plagioclase, orthoclase, and augite.

U. Andesite-porphyry, Zosel mining district, near Daylight. Somewhat altered. Contains augite, andesine, and olivine in a groundmass of plagioclase, augite and iron oxide. Ferromagnesian minerals altered to serpentine.

Analysis S by Hillebrand, record No. 1692. P, Q, R, T, and U by Stokes, record Nos. 1686, 1787.

	P.	Q.	R.	S.	T.	U.
SiO_2	67.55	74.34	75.30	69.95	62.53	54.61
Al_2O_3	15.68	12.97	11.95	15.14	19.01	15.23
Fe_2O_3	.98	.75	2.17	.38	1.96	3.51
FeO	1.02	.54		.83	1.44	4.80
MgO	1.11	.86	.05	.56	1.29	4.69
CaO	2.51	.85	.62	1.45	5.17	7.41
Na_2O	4.15	2.49	3.09	2.70	3.45	1.46
K_2O	2.86	4.72	4.96	6.36	3.30	2.70
H_2O at 110°	.38	1.03	.36	.40	.21	.32
H_2O above 110°	2.76	1.11	.61	.91	.45	2.47
TiO_2	.34	.18	.17	.24	.65	.86
P_2O_5	.12	.07	trace	.10	.17	.35
ZrO_2	none	.05	....	.02	....	none
MnO	trace	trace	trace	.08	.03	.09
SrO	.03	trace	none	.02	.04	.04
BaO	.11	.07	trace	.13	.13	.11
Li_2O	none	trace	trace	trace	trace	trace
CO_2	none	none	none	.37	none	1.46
SO_3	none	.03	.44	....	none	none
FeS_2	....	....	....	[a] .39	....	....
Cl	.05	none	trace	undet.	....	none
Cu	....	....	....	.03	....	....
Organic matter	....	....	.45	....	....	....
	99.65	100.06	100.17	100.06	99.83	100.11

[a] Other sulphides than pyrite present.

3. CRAZY MOUNTAINS.

The greater number of the rocks in this group were received from J. E. Wolff, who has supplied the petrographic data. The few exceptions are properly indicated. The three tinguaites and the elæolite-syenite were described by Wolff and Tarr in Bull. Mus. Compar. Zoölogy, vol. 16, No. 12, 1893, in a paper upon "Acmite-Trachyte from the Crazy Mountains." The renaming of these rocks is due to Wolff. The analyses, except when otherwise stated, are by W. F. Hillebrand, record No. 1438.

A. Granitite, Big Timber Creek. Small dikes in main diorite stock. Contains quartz, orthoclase, plagioclase (oligoclase), and biotite.

B. Hornblende-granitite, main stock, Big Timber Creek. Contains biotite, hornblende, quartz, orthoclase, and plagioclase (oligoclase).

C. Granite-porphyry, intrusive sheet, north part of the mountains. Contains orthoclase, albite, quartz, biotite, and green hornblende in a groundmass of quartz and untwinned feldspar.

D. Porphyrite, intrusive sheet, Sweet Grass Creek. Contains hornblende and andesine in a groundmass of plagioclase, orthoclase, and quartz, with accessory magnetite.

E. Porphyrite, dike in contact zone, Sweet Grass Creek. Contains brown hornblende, biotite, and labradorite in a groundmass of plagioclase, biotite, and hornblende, with a little quartz and orthoclase.

F. Porphyrite, intrusive sheet, middle peak of Three Peaks. Contains andesine, hornblende, augite, and biotite in a groundmass of plagioclase, orthoclase, and quartz.

	A.	B.	C.	D.	E.	F.
SiO_2	74.37	64.47	69.93	66.28	64.49	61.08
Al_2O_3	13.12	15.45	14.95	16.21	17.25	16.62
Fe_2O_3	.73	2.25	1.78	.80	.86	2.87
FeO	.87	2.25	.55	2.06	2.42	2.56
MgO	.35	2.68	.60	1.57	1.24	1.65
CaO	1.26	3.63	1.46	3.53	3.79	3.66
Na_2O	2.57	4.54	5.30	4.36	4.19	4.75
K_2O	6.09	3.19	3.99	3.20	4.15	3.90
H_2O at 110°	.05	.05	.12	.12	.06	.44
H_2O above 110°	.25	.63	.32	.78	.54	.97
TiO_2	.29	.75	.33	.50	.51	.73
P_2O_5	.06	.22	.33	.20	.23	.63
MnO	trace	.06	trace	trace	trace	trace
SrO	trace	.04	.06	.05	.08	.08
BaO	.10	.23	.29	.34	.30	.32
Li_2O	trace	trace?	trace	trace?	trace	trace
	100.11	100.44	100.01	100.00	100.11	100.26

G. Porphyrite, intrusive sheet, north of Shields River Basin. Contains plagioclase, hornblende, and biotite, in a groundmass of plagioclase, a little orthoclase, augite, hornblende, and magnetite.

H. Porphyrite, intrusive sheet, northern part of the mountains. Contains brown hornblende, green augite, and plagioclase, in a groundmass of plagioclase, augite, and magnetite, with accessory apatite.

I. Syenite, ridge north of Shields River Basin. Contains hornblende, green augite, and anorthoclase, with accessory sphene, apatite, and magnetite.

J. Diabase-porphyrite (?), dike south of Shields River Basin. Contains labradorite and decomposed augite in a groundmass of plagioclase, epidote, and chlorite.

K. Diorite-porphyrite, Big Timber Creek. Contains labradorite, augite, hornblende, biotite, orthoclase, quartz, magnetite, and apatite.

L. Quartz-diorite, main stock on Sweet Grass Creek. Contains hornblende, biotite, augite, labradorite, orthoclase, and quartz, with accessory apatite, magnetite, olivine, and hypersthene.

	G.	H.	I.	J.	K.	L.
SiO_2	56.75	54.69	58.28	58.28	54.56	53.48
Al_2O_3	16.40	16.53	17.89	19.37	17.58	19.35
Fe_2O_3	4.78	4.54	3.20	1.35	4.30	2.37
FeO	3.10	2.83	1.73	2.98	4.98	4.90
MgO	3.22	2.99	1.51	1.30	2.86	3.67
CaO	5.34	5.34	3.69	4.78	6.00	7.55
Na_2O	4.19	5.19	5.89	4.40	4.43	4.07
K_2O	3.36	3.93	5.34	3.75	2.70	1.41
H_2O at 110°	.40	.32	.17	.44	.02	.16
H_2O above 110°	.82	1.05	.98	1.78	.38	.80
TiO_2	.86	.91	.64	.96	1.34	1.07
P_2O_5	.52	.73	.26	.35	.60	.62
MnO	.17	.07	.06	.07	.06	.06
SrO	.10	.06	.05	.09	.08	.11
BaO	.33	.37	.36	.25	.27	.19
Li_2O	trace?	trace?	trace	trace?	trace	trace?
Cl	....	trace	....	....	....	....
CO_2	....	.83	....	.33	....	.08
	100.34	100.38	100.05	100.48	100.16	99.89

M. Diorite, head of Rock Creek. Contains biotite, labradorite, and augite, in a groundmass of plagioclase, orthoclase, and quartz, with accessory magnetite, apatite, and hornblende.

N. Diorite, main stock, Big Timber Creek. Contains biotite, augite, labradorite, quartz, orthoclase, apatite, and magnetite.

O. Olivine-gabbro, Big Timber Creek. Contains labradorite (?), brown hornblende, augite, olivine, and magnetite.

P. Rock from Musselshell River, north of Crazy Mountains. Received from J. S. Diller, but undescribed. Regarded by W. H. Weed as monchiquite. Analysis by L. G. Eakins, record No. 1021.

Q. Hornstone, metamorphosed shale, contact zone, Sweet Grass Creek. An aggregate of augite, quartz, triclinic feldspar, and biotite.

	M.	N.	O.	P.	Q.
SiO_2	57.97	50.73	40.42	44.66	57.31
Al_2O_3	15.65	19.99	9.98	12.12	14.24
Fe_2O_3	.73	3.20	9.83	5.81	1.00
FeO	2.80	4.66	10.67	3.20	3.24
MgO	4.96	3.48	11.56	8.77	4.60
CaO	10.93	8.55	10.78	8.14	11.31
Na_2O	3.03	4.03	1.26	4.47	2.64
K_2O	3.16	1.89	.60	2.75	4.55
H_2O at 110°	.22	.11	.45	4.33	.25
H_2O above 110°	.38	.66	1.17		.24
TiO_2	.60	1.59	2.51	1.02	.52
P_2O_5	.15	.81	.63	2.02	.18
(CoNi)O	....	....	.02	....	....
MnO	trace	.05	.25	.21	.08
SrO	.02	.11	.02	....	trace?
BaO	.09	.27	.05	....	.19
Li_2O	trace	trace	trace	....	trace?
CO_2	....	....	....	2.19	.17
Cl	trace	....	....	....	....
F	trace	....	....	....	....
	100.69	100.13	100.20	99.69	100.52

R. Elæolite-syenite, Peaked Butte, northeast side of the mountains. Described by Wolff and Tarr, *l. c.* Contains anorthoclase, augite, occasionally sodalite, ægirine, apatite, magnetite, and some interstitial nephelite. Analysis by W. H. Melville, record No. 1291.

Ra. Anorthoclase from R. Analysis by W. F. Hillebrand, record No. 1297.

S. Tinguaite, var. sölvsbergite, intrusive sheet north of Shields River.

T. Tinguaite, var. sölvsbergite, dike north part of mountains.

U. Tinguaite, var. sölvsbergite, dike at head of Sixteenmile Creek.

S, T, and U are the rocks described by Wolff and Tarr in their paper upon "Acmite-Trachyte." Mineral composition the same as under R. Analyses by W. H. Melville, record No. 1291.

	R.	Ra.	S.	T.	U.
SiO_2	59.66	62.31	58.70	62.17	64.33
Al_2O_3	16.97	22.63	19.26	18.58	17.52
Fe_2O_3	3.18		3.37	2.15	3.06
FeO	1.15		.58	1.05	.94
MgO	.80		.76	.73	.34
CaO	2.32	.63	1.41	1.57	.56
Na_2O	8.38	7.68	8.55	7.56	7.30
K_2O	4.17	4.79	4.53	3.88	4.28
H_2O at 105°	.07	.16	.07	.07	.04
H_2O above 105°	2.53	.72	2.57	1.63	.95
TiO_2	trace		trace	trace	trace
P_2O_5	.14		.10	.11	trace
MnO	.19		.10	trace	.35
SrO		.57			
BaO		.77			
	99.56	100.26	100.00	99.50	99.67

V. Theralite, Gordons Butte. Contains green augite, ægirine, biotite, olivine, nephelite, sodalite, and a feldspar, partly sanidine, containing K, Na, Ba, Sr, and Ca; also accessory apatite, magnetite, and sphene.

W. Theralite, Gordons Butte; another sample. Analysis by E. A. Schneider, record No. 1281.

X. Theralite, north of Alabaugh Creek. Descrided by Wolff for the Educational Series. Contains augite, ægirine, biotite, olivine, magnetite, apatite, nephelite partly zeolitized, a mineral of the sodalite group, sanidine, and analcite. Analysis by Schneider, No. 1281.

Rocks V, W, and X are described by Wolff in Bull. 150, pp. 197, 199.

Y. Altered theralite, head of Shields River, west of Loco Mountain. Received from W. H. Weed. Analysis by H. N. Stokes, record No. 1547.

Z. Hornblende-picrite, Conical Peak. Data supplied by J. P. Iddings. Contains hornblende, plagioclase, hypersthene, augite, olivine, very little primary quartz, and probably some magnetite and apatite. Analysis by L. G. Eakins, record No. 1379.

	V.	W.	X.	Y.	Z.
SiO_2	44.65	44.31	47.67	48.90	45.71
Al_2O_3	13.87	17.20	18.22	14.70	10.80
Fe_2O_3	6.06	4.64	3.65	4.14	4.43
FeO	2.94	3.73	3.85	3.68	9.35
MgO	5.15	6.57	6.35	3.95	13.75
CaO	9.57	10.40	8.03	8.26	10.48
Na_2O	5.67	4.45	4.93	5.22	1.58
K_2O	4.49	3.64	3.82	.56	.85
H_2O at 110°	.96	.77	.38	.52	.97
H_2O above 110°	2.10	3.30	2.97	2.44	
TiO_2	.95	undet.	undet.	.95	1.83
P_2O_5	1.50			.79	.11
Cr_2O_3					.10
MnO	.17	.10	.28	.03	.17
SrO	.37			.13	
BaO	.76			.31	trace
Li_2O	trace			trace	
CO_2	.11			5.42	
SO_3	.61			.04	
Cl	trace				
	99.92	99.11	100.15	100.04	100.13

4. LITTLE BELT MOUNTAINS.

Rocks collected by W. H. Weed and L. V. Pirsson, who furnish the petrographic data. To be described in a paper on the Neihart and Barker mining districts in Pt. III of the 20th Ann. Analyses by W. F. Hillebrand, record No. 1476, and H. N. Stokes, record No. 1547.

A. Quartz-porphyry, Yogo Peak, sheet at head of Belt and Running Wolf creeks. Phenocrysts of orthoclase and quartz in a groundmass of quartz and alkali feldspar, with a little white mica and some kaolin. Chlorite, limonite, and calcite are also present, pseudomorphous after biotite and perhaps hornblende. Total amount of secondary minerals very small. Analysis by Hillebrand.

B. Granite-porphyry, Wolf Butte. Phenocrysts of quartz, orthoclase, plagioclase, and biotite in a groundmass of quartz and alkali feldspar. A little apatite and iron ore, with secondary calcite, limonite, chlorite, and white mica. Analysis by Stokes.

C. Granite-porphyry, top of Barker Mountain. Phenocrysts of orthoclase, oligoclase, biotite, green hornblende, sphene, and iron ore, in a groundmass of quartz and alkali feldspar. Also a little apatite and some secondary chlorite and limonite. Analysis by Stokes.

D. Syenite, Wright and Edwards mine, Hughesville, near Barker. Very fresh rock. Contains magnetite, ilmenite, hornblende, anorthoclase, albite, subordinate quartz, a little chlorite, calcite, and limonite, and white mica in traces. Analysis by Stokes.

E. Syenite, Yogo Peak. Described in Amer. Journ. Sci., 3d series, vol. 50, p. 471. Contains apatite, sphene, iron ore, pyroxene, hornblende, biotite, orthoclase, oligoclase, and quartz, with traces of chlorite and limonite and a little kaolin. Analysis by Hillebrand.

F. Syenite-porphyry, dike at head of Sheep Creek. Phenocrysts of orthoclase, some plagioclase, and green hornblende, in a groundmass of alkali feldspar, with some quartz. Also contains a little apatite and iron ore, with some secondary calcite and kaolin. Analysis by Hillebrand.

	A.	B.	C.	D.	E.	F.
SiO_2	73.12	69.68	68.60	64.64	61.65	66.29
Al_2O_3	14.27	14.97	16.13	16.27	15.07	15.09
Fe_2O_3	.51	.79	2.22	2.42	2.03	1.37
FeO	.26	.34	.44	1.58	2.25	1.17
MgO	.24	.66	.72	1.27	3.67	2.39
CaO	1.10	2.10	1.36	2.65	4.61	2.38
Na_2O	3.43	3.38	4.37	4.39	4.35	3.96
K_2O	4.90	4.40	4.89	4.98	4.50	4.91
H_2O at 110°	.68	1.09	.20	.09	.26	.39
H_2O above 110°	.73	.92	.58	.27	.41	.60
TiO_2	.08	.28	.32	.51	.56	.27
P_2O_5	.03	.17	.18	.37	.33	.15
Cr_2O_3	none	....	....	....	trace	none
MnO	.06	trace	trace	trace	.09	.06
SrO	trace	.06	.09	.08	.10	.07
BaO	trace	.14	.27	.18	.27	.30
Li_2O	trace	trace	trace	....	trace	trace
CO_2	.77	.88	....	.37	....	.45
SO_3	....	trace	trace	trace	....	....
Cl	....	trace	trace	.05	....	....
	100.18	99.86	100.37	100.12	100.15	99.85

G. Syenite-porphyry, intrusive sheet, between Yogo Peak and Big Baldy Mountain. Abundant phenocrysts of hornblende and orthoclase, with less biotite and plagioclase, in a groundmass of alkali feldspar with accessory quartz. Also contains iron ore and apatite, with secondary calcite, chlorite, sericite, and kaolin. Analysis by Hillebrand.

H. Granite-syenite-porphyry, north end of Thunder Mountain. Phenocrysts of orthoclase, oligoclase, hornblende, and biotite, in a groundmass of alkali feldspar and very abundant quartz. Also contains a little sphene, iron ore, and apatite, very little secondary chlorite and limonite, and a trace of kaolin. Analysis by Stokes.

I. Quartz-syenite-porphyry, top of Big Baldy Mountain. Phenocrysts of orthoclase, plagioclase, biotite, iron ore, brown hornblende, and sphene, in a groundmass of quartz and alkali feldspar. Also contains a little apatite, with traces of chlorite, limonite, and kaolin. Analysis by Hillebrand.

J. Syenite-diorite-porphyry, talus slope on west side of Bear Park. Phenocrysts of biotite, hornblende, plagioclase, and orthoclase, in a groundmass of quartz and alkali feldspar. Also contains a little magnetite, chlorite, white mica, and apatite. Analysis by Stokes.

K. Diorite-porphyry, Steamboat Mountain. Phenocrysts of orthoclase, plagioclase, hornblende, and biotite, with a little iron ore and apatite, in a groundmass of orthoclase, plagioclase, and quartz. Analysis by Stokes.

L. Diorite, Carpenter Creek, near Neihart. Contains green hornblende, biotite, and plagioclase, with some apatite, iron ore, calcite, kaolin, and muscovite, and a very little quartz and orthoclase. Analysis by Hillebrand.

	G.	H.	I.	J.	K.	L.
SiO_2	62.58	67.44	67.04	64.95	62.18	55.13
Al_2O_3	16.42	15.78	15.25	15.44	15.77	20.27
Fe_2O_3	2.46	1.58	1.69	2.02	1.83	1.52
FeO	1.96	.85	1.13	1.60	2.44	4.29
MgO	1.84	1.43	1.75	2.65	3.55	1.80
CaO	2.47	2.38	2.17	3.07	4.13	7.05
Na_2O	4.57	4.11	4.09	4.25	3.92	4.31
K_2O	3.91	4.87	5.10	3.87	3.91	2.84
H_2O at 110°	.38	.32	.56	.26	.30	.14
H_2O above 110°	1.40	.70	.51	.85	.70	.95
TiO_2	.40	.32	.20	.39	.55	.74
P_2O_5	.33	.21	.21	.25	.32	.40
MnO	.08	trace	.05	trace	trace	.13
SrO	.10	.09	.03	.10	.16	.06
BaO	.41	.24	.33	.35	.43	.11
Li_2O	trace	trace	trace?	....	trace	trace
CO_2	.77	....	....	....	....	.26
SO_3	....	trace	....	.02	trace	....
Cl	....	trace	....	.04	.04	....
	100.08	100.32	100.11	100.11	100.23	100.00

M. Minette, intrusive sheet, head of Sheep Creek. Chiefly biotite, augite, and orthoclase, with accessory apatite, plagioclase, quartz, and iron ore, and some secondary calcite, chlorite, and kaolin. Analysis by Hillebrand.

N. Monzonite, Yogo Peak. Described in Amer. Journ. Sci., 3d series, vol. 50, p. 473, and 4th series, vol. 1, p. 356. Contains apatite, sphene, iron ore, pyroxene, hornblende, biotite, orthoclase, and oligoclase, and a little secondary kaolin. Analysis by Hillebrand.

O. Monchiquite, dike on Big Baldy Mountain. Contains much pyroxene, a few serpentinized olivines, iron ore, and apatite in a colorless base of analcite. Analysis by Hillebrand.

P. Monchiquite, dike on Bandbox Mountain. Contains olivine, augite, biotite, analcite, and apatite, with traces of serpentine and chlorite. Analysis by Stokes.

Q. Shonkinite, Yogo Peak. Described in Amer. Journ. Sci., 3d series, vol. 50, p. 474. Chiefly augite and orthoclase, with a considerable amount of accessory biotite, iron ore, and andesine, less apatite and olivine, and a trace of kaolin. Analysis by Hillebrand.

	M.	N.	O.	P.	Q.
SiO_2	52.26	54.42	48.35	48.39	48.98
Al_2O_3	13.96	14.28	13.27	11.64	12.29
Fe_2O_3	2.76	3.32	4.38	4.09	2.88
FeO	4.45	4.13	3.23	3.57	5.77
MgO	8.21	6.12	8.36	12.55	9.19
CaO	7.06	7.72	9.94	7.64	9.65
Na_2O	2.80	3.44	3.35	4.14	2.22
K_2O	3.87	4.22	3.01	3.24	4.96
H_2O at 110°	1.53	.22	.90	.28	.26
H_2O above 110°	1.34	.38	2.89	2.56	.56
TiO_2	.58	.80	.52	.73	1.44
P_2O_5	.52	.59	.40	.45	.98
Cr_2O_3	trace	trace	trace	.07	trace
NiO	....	....	.04	....	....
MnO	.14	.10	.19	trace	.08
SrO	.05	.13	.09	.15	.08
BaO	.23	.32	.54	.32	.43
Li_2O	trace	trace	trace	trace	trace
SO_3	....	....	....	.08	....
Cl	....	....	....	trace	....
CO_2	.49	....	.30	....	....
F	....	....	.25	....	.22
	100.25	100.19	100.01	99.90	99.99

5. CASTLE MOUNTAIN DISTRICT.

Rocks described by Weed and Pirsson in Bull. 139. Analyses made by Pirsson in the laboratory of the Sheffield Scientific School.

A. Rhyolite, between Fourmile and Fivemile creeks, near Smith River. Contains quartz, soda orthoclase, tourmaline, and a little iron ore and zircon. P. R. C. 560.

B. Quartz-tourmaline-porphyry, upper Fourmile Creek. Contains quartz, orthoclase, plagioclase, tourmaline, fluorite, and a little white mica, apatite, and zircon. P. R. C. 558.

C. Granite, Elk Peak. Contains quartz, orthoclase, oligoclase, biotite, hornblende, iron ore, apatite, sphene, and zircon. The last three minerals are rare. P. R. C. 551.

D. Quartz-porphyry, sheet on ridge between Fourmile and Checkerboard creeks. Contains quartz, plagioclase, an untwinned feldspar and biotite, with occasional grains of iron ore and crystals of apatite and zircon. P. R. C. 557.

E. Rhyolite-pitchstone, forks of Checkerboard Creek. Essentially glass, inclosing grains of iron ore. P. R. C. 561.

F. Aplitic granite, dike between Blackhawk and Robinson. Contains quartz and unstriated feldspar, some plagioclase, and occasional biotite. P. R. C. 553.

G. Quartz-porphyry, Musselshell Canyon. Contains quartz, biotite, plagioclase, apatite, iron ore, and zircon. P. R. C. 556.

	A.	B.	C.	D.	E.	F.	G.
SiO_2	74.90	74.82	72.48	72.38	72.56	72.88	71.67
Al_2O_3	13.64	13.80	13.14	14.71	12.33	12.90	15.82
Fe_2O_3	.66	.37	1.66	1.09	.80	.74	1.18
FeO	.50	.30	1.02	.82	.82	1.05	.35
MgO	trace	.10	.15	.70	trace	.75	.13
CaO	.61	.17	1.04	.67	trace	.81	.25
Na_2O	4.22	4.33	4.22	4.28	5.36	3.72	4.46
K_2O	4.64	4.81	4.88	4.15	3.08	5.03	4.45
H_2O	.33	.83	.42	.92	4.59	1.22	1.21
TiO_2	.15	.25	.32	.10	.20	.45	.10
MnO	trace	trace	trace	trace	trace	.05	trace
Li_2O	trace	trace	trace	trace	....	....	....
	99.65	99.78	99.33	99.82	99.74	99.60	99.62
Sp. gr.	2.61	2.59	2.62	2.61	2.37	2.64	2.60

H. Feldspar-porphyry, dike below Castle. Contains orthoclase, less plagioclase, hornblende, biotite partly altered to chlorite, sometimes allanite, and occasional iron ore, apatite, and zircon. P. R. C. 555.

I. Rhyolitic tuff, near forks of Checkerboard Creek. Contains fragments of shale, quartz, plagioclase, sanidine, and hornblende, in a brownish material carrying pumiceous glass. Much decomposed, with formation of kaolin. P. R. C. 562.

J. Syenitic mass included in granite, head of Cottonwood Creek. Contains orthoclase, plagioclase, quartz, hornblende, biotite, apatite, and iron ore. A hornblende-mica-syenite. P. R. C. 554.

K. Diorite, between Blackhawk and Robinson. Contains plagioclase, orthoclase, quartz, biotite, diallage, hypersthene, iron ore, apatite, and zircon. P. R. C. 559.

L. Basalt, Volcano Butte. Contains labradorite, augite, olivine, a little serpentine, occasional quartz grains, small patches of glass, iron ore, chiefly ilmenite, apatite, a trace of calcite, and a mineral which may be nephelite or analcite. P. R. C. 565.

M. Augite-vogesite, dike on west side of upper Fourmile Creek. Contains augite, hornblende, iron ore, a little plagioclase, orthoclase, calcite, and some decomposition products. P. R. C. 563.

N. Monchiquite-like dike rock, west side of upper Willow Creek. Contains augite, olivine, biotite, ilmenite, and a colorless base which appears to be partially zeolitized glass. Also a little serpentine, chlorite, and calcite. P. R. C. 564.

	H.	I.	J.	K.	L.	M.	N.
SiO_2	65.87	61.21	61.87	56.80	46.52	45.15	42.46
Al_2O_3	16.82	15.67	17.26	18.30	10.48	15.39	12.04
Fe_2O_3	1.58	4.06	2.35	1.64	4.40	2.76	3.19
FeO	1.23	.62	2.43	5.58	7.79	5.64	5.34
MgO	1.54	1.58	1.82	3.63	10.58	6.38	12.40
CaO	2.65	2.18	3.23	5.31	9.49	8.83	12.14
Na_2O	4.72	1.57	5.18	4.35	3.12	2.67	1.21
K_2O	3.15	2.75	3.83	3.28	1.55	2.77	2.68
H_2O	1.43	10.20	1.07	.53	1.79	2.85	4.03
TiO_2	.37	.56	.87	.46	2.98	2.80	2.47
P_2O_5	trace	....	trace	trace	.83	.56	.84
X[a]	....	....	....	....	.73	....	....
MnO	trace	.10	.03	trace	.11	.14	.16
Li_2O	....	trace	trace	trace	trace	trace	trace
CO_2	....	....	....	....	trace	4.27	.55
	99.36	100.50	99.94	99.88	100.37	100.21	99.51
Sp. gr	2.62	....	2.67	2.83	2.99	2.70	2.94

[a] Unseparated rare earths or metallic acids, such as columbic, tantalic, etc.

6. HIGHWOOD MOUNTAINS.

Rocks collected by W. H. Weed and L. V. Pirsson, who furnish the petrographic data. Analyses made in the laboratory of the Sheffield Scientific School, under the direction of Professor Pirsson.

A. Trachy-andesitic breccia, head of north fork of Willow Creek. Contains hornblende, biotite, iron ore, apatite, plagioclase, and orthoclase, with a little kaolin and limonite. E. B. Hurlbut and B. Barnes, analysts.

B. Trachyte, dike 1 mile north of divide in Highwood Gap. Contains abundant phenocrysts of orthoclase and augite in a groundmass of the same minerals; also a little biotite, apatite, and iron ore, and some secondary kaolin. E. B. Hurlbut, analyst.

C. Trachyte, dike north end of South Mountain. Contains phenocrysts of alkali feldspar, ægirine-augite, and melanite, in a groundmass of alkali feldspar. Apatite, iron ore, a trace of calcite, and some kaolin are also present. H. W. Foote, analyst.

D. Trachyte, dike on Aspen Creek. Contains alkali-hornblende and alkali-feldspar phenocrysts, in a groundmass of alkali feldspars; also some apatite and iron ore. Rock stained by limonite. H. W. Foote, analyst.

E. Trachyte, dike at head of Shonkin Creek. Contains augite, biotite, iron ore, and orthoclase, in a groundmass of alkali feldspar; also apatite and some kaolin. W. M. Bradley, analyst.

	A.	B.	C.	D.	E.
SiO_2	59.24	58.04	57.18	55.23	51.94
Al_2O_3	13.84	17.24	18.54	18.31	15.78
Fe_2O_3	5.46	2.49	3.65	4.90	4.07
FeO	1.36	1.24	1.15	2.06	3.17
MgO	4.79	1.79	.69	1.85	3.48
CaO	5.60	3.50	2.31	3.62	6.04
Na_2O	3.13	3.37	4.48	4.02	3.44
K_2O	4.22	10.06	8.58	6.43	7.69
H_2O	2.02	1.95	2.10	1.84	2.17
TiO_2	.22	.30	.30	.42	.39
P_2O_5	.34	.22	.05	.58	.59
MnO	trace	trace	trace	trace	trace
SrO	none	undet	trace	trace	.28
BaO	trace	undet	.49	.46	.42
SO_3	.08	trace	.06	.23	.29
CO_2	none	....	....	none	....
Cl	.04	.38	.77	.32	.08
	100.34	100.58	100.35	100.27	99.83
Less O	.01	.09	.17	.08	.02
	100.33	100.49	100.18	100.19	99.81

F. Syenite, top of Palisade Butte. Contains augite, iron ore, apatite, alkali feldspar, a little biotite, some limonite in cracks, much natrolite, and possibly other zeolites. H. W. Foote, analyst.

G. Leucite-syenite, head of Davis Creek. Contains augite, iron ore, olivine, biotite, apatite, alkali feldspar, leucite, and some zeolites, with traces of limonite and serpentine. E. B. Hurlbut, analyst.

H. Monchiquite, dike east side of Highwood Gap. Contains augite, olivine, biotite, iron ore, apatite, and analcite, with some serpentine and a little kaolin. H. W. Foote, analyst.

I. Leucite-basalt, saddle between Highwood and Pinewood peaks. Contains augite, iron ore, leucite, apatite, altered olivine, chlorite, calcite, and zeolites. H. W. Foote, analyst.

J. Leucite-basalt or leucite-monchiquite, dike on Arrow Peak. Phenocrysts of augite, olivine, and biotite, with some leucite, in a groundmass of the same minerals. Also analcite, iron ore, and apatite. H. W. Foote, analyst.

	F.	G.	H.	I.	J.
SiO_2	50.11	49.59	47.82	47.98	46.04
Al_2O_3	17.13	14.51	13.56	13.34	12.23
Fe_2O_3	3.73	3.51	4.73	4.09	3.86
FeO	3.28	5.53	4.54	4.24	4.60
MgO	2.47	6.17	7.49	7.01	10.38
CaO	5.09	9.04	8.91	9.32	8.97
Na_2O	3.72	3.52	4.37	3.51	2.42
K_2O	7.47	5.60	3.23	5.00	5.77
H_2O	4.47	1.95	3.37	2.10	2.87
TiO_2	.82	.36	.67	.58	.64
P_2O_5	.67	.15	1.10	1.03	1.14
MnO	trace	trace	trace	trace	trace
SrO	.35	.21	.21	.14	.25
BaO	.63	.49	.16	.50	.48
SO_3	.08	.02	trace	trace	trace
CO_2	....	....	....	1.24	....
Cl	.07	.13	.04	.21	.11
	100.09	100.78	100.20	100.29	99.76
Less O	.02	.03	.01	.07	.03
	100.07	100.75	100.19	100.22	99.73

K. Missourite, head of Shonkin Creek. Described in Amer. Journ. Sci., 4th series, vol. 2, p. 315. Contains apatite, iron ore, olivine, biotite, augite, and leucite, the two latter being the chief minerals. Some zeolites and analcite are also present. E. B. Hurlbut, analyst.

L. Pseudo leucite-syenite, head of Shonkin Creek. Contains augite, olivine, biotite, iron ore, apatite, orthoclase, nephelite, zeolites, and traces of serpentine, limonite, and kaolin. Contains pseudomorphs after leucite. E. B. Hurlbut, analyst.

M. Monzonite, Highwood Peak. Contains augite, biotite, iron ore, apatite, plagioclase, and alkali feldspar. E. B. Hurlbut, analyst.

N. Monzonite, Middle Peak. Contains augite, olivine, biotite, iron ore, apatite, plagioclase, and orthoclase. The two latter, with augite, are the chief minerals. E. B. Hurlbut, analyst.

	K.	L.	M.	N.
SiO_2	46.06	51.75	51.00	52.05
Al_2O_3	10.01	14.52	17.21	15.02
Fe_2O_3	3.17	5.08	2.41	2.65
FeO	5.61	3.58	4.23	5.52
MgO	14.74	4.55	6.19	5.39
CaO	10.55	7.04	9.15	8.14
Na_2O	1.31	2.93	2.88	3.17
K_2O	5.14	7.61	4.93	6.10
H_2O	1.44	2.25	.63	.35
TiO_2	.73	.23	.13	.47
P_2O_5	.21	.18	.33	.21
MnO	trace	trace	trace	trace
SrO	.20	.07	.14	.28
BaO	.32	.30	.34	.42
SO_3	.05	trace	.03	.02
Cl	.03	.05	trace	.24
	99.57	100.14	99.60	100.03
Less O	.01	.01		.06
	99.56	100.13		99.97

The following rock and separations, from Square Butte, at the east end of the Highwood Mountains, are described by Lindgren in Amer. Journ. Sci., 3d series, vol. 45, p. 286. Analyses by W. H. Melville, record No. 1268.

A. Post-Cretaceous sodalite-syenite. Contains orthoclase, some albite, hornblende, sodalite, analcite, and apatite. Orthoclase predominates. The sodalite amounts to 8 per cent. P. R. C. 184.

B. Hornblende separated from A. Near barkevikite.

C. Sodalite from A. Sp. gr. 2.265.

D. Analcite from A. Sp. gr. 2.255.

In addition, the orthoclase gave 3.88 per cent Na_2O and 11.03 per cent K_2O. A separation of mixed feldspars, sp. gr. 2.56, gave 6.08 per cent Na_2O and 8.91 per cent K_2O.

	A.	B.	C.	D.
SiO_2	56.45	38.41	41.56	49.54
Al_2O_3	20.08	17.65	29.48	25.07
Fe_2O_3	1.31	3.75	....	....
FeO	4.39	21.75	.49	.40
MgO	.63	2.54	.15	.20
CaO	2.14	10.52	.49	.22
Na_2O	5.61	2.95	19.21	15.32
K_2O	7.13	1.95	.91	.89
H_2O at 100°	.26	....	.45	undet.
H_2O above 100°	1.51	.24	3.73	undet.
TiO_2	.29	....	....	....
P_2O_5	.13	....	....	....
NiO	trace	trace	....	....
MnO	.09	.15	....	....
Cl	.43	....	4.79	1.67
	100.45	99.91	101.26	93.31
Less O	.10	....	1.08	.38
	100.35	....	100.18	92.93

7. LITTLE ROCKY MOUNTAINS.

Granite-syenite-porphyry. Described by Weed and Pirsson, Journal of Geology, vol. 4, p. 399. Contains orthoclase, quartz, oligoclase, iron oxides, and a little muscovite. Analysis by H. N. Stokes, record No. 1558. P. R. C. 905.

SiO_2	68.65	P_2O_5	trace
Al_2O_3	18.31	MnO	trace
Fe_2O_3	.56	SrO	.10
FeO	.08	BaO	.13
MgO	.12	Li_2O	trace
CaO	1.00	SO_3	trace
Na_2O	4.86	Cl	.03
K_2O	4.74	F	trace
H_2O at 110°	.27		99.88
H_2O above 110°	.83		
TiO_2	.20		

8. BEARPAW MOUNTAINS.

Described by Weed and Pirsson, Amer. Journ. Sci., 4th series, vol. 1, pp. 283 and 351, and vol. 2, pp. 136 and 188. Analyses by H. N. Stokes, record Nos. 1558 and 1572.

A. Quartz-syenite-porphyry, Gray Butte. Contains anorthoclase, microlites of plagioclase, ægirite, augite, quartz, and apatite, with an occasional zircon and very few biotite leaves. P. R. C., 897.

B. Quartz-syenite, Beaver Creek stock. Contains orthoclase, albite, quartz, augite, and iron oxides, with very little biotite, hornblende, and sphene. P. R. C., 900.

C. Basic syenite or monzonite (yogoite), Beaver Creek. Contains orthoclase, plagioclase, diopside, biotite, iron oxides, and apatite. P. R. C., 902.

	A.	B.	C.
SiO_2	66.22	68.34	52.81
Al_2O_3	16.22	15.32	15.66
Fe_2O_3	1.98	1.90	3.06
FeO	.16	.84	4.76
MgO	.77	.54	4.99
CaO	1.32	.92	7.57
Na_2O	6.49	5.45	3.60
K_2O	5.76	5.62	4.84
H_2O at 110°	.08	.15	.16
H_2O above 110°	.24	.30	.93
TiO_2	.22	.21	.71
P_2O_5	.10	.13	.75
MnO	trace	.07	trace
SrO	.06	.04	.09
BaO	.29	.08	.24
Li_2O	trace	none	trace
SO_3	.02	trace	trace
Cl	.04	.04	.07
F	trace	none?	trace
	99.97	99.95	100.24

D. Shonkinite, Beaver Creek. Contains anorthoclase, diopside, biotite, iron oxides, and apatite, with very little olivine and probably a trace of nephelite. P. R. C. 901.

E. Leucitite, Bearpaw Mountains. An olivine-free leucite-basalt. Contains leucite, augite, iron oxides, rarely biotite, and very little glassy base. P. R. C. 903.

F. Tinguaite, dike on Bear Creek. Contains orthoclase, nephelite, cancrinite, augite, ægirite, apatite, a little sodalite, and a doubtful fibrous hornblende. P. R. C. 899.

G. Pseudo leucite-sodalite-tinguaite, Beaver Creek. Contains orthoclase, nephelite, sodalite, nosean, ægirite, diopside, and fluorite. P. R. C. 904.

	D.	E.	F.	G.
SiO_2	50.00	46.51	57.46	51.93
Al_2O_3	9.87	11.86	15.40	20.29
Fe_2O_3	3.46	7.59	4.87	3.59
FeO	5.01	4.39	.87	1.20
MgO	11.92	4.73	1.37	.22
CaO	8.31	7.41	2.59	1.65
Na_2O	2.41	2.39	5.48	8.49
K_2O	5.02	8.71	9.44	9.81
H_2O at 110°	.17	1.10	.09	.10
H_2O above 110°	1.16	2.45	.82	.99
TiO_2	.73	.83	.60	.20
P_2O_5	.81	.80	.21	.06
Cr_2O_3	.11	none	....	....
NiO	.07	.04	....	....
CoO	....	trace	....	....
MnO	trace	.22	trace	trace
CuO	....	trace	....	....
SrO	.07	.16	.16	.07
BaO	.32	.50	.60	.09
Li_2O	trace	trace	trace	trace
SO_3	.02	.05	.13	.67
CO_2	.31	none	.13	.25
Cl	.08	.04	.20	.70
F	.16	trace	trace	.27
	100.01	99.78	100.42	100.58
Less O	.08	.02	.05	.27
	99.93	99.76	100.37	100.31

IDAHO.

Rocks collected by Waldemar Lindgren, who furnishes the petro-raphic data. Those from Silver City and Hailey will be described in th Ann., Part III.

A. Quartz-monzonite, Idaho-Democrat mine, Hailey. Contains uartz, orthoclase, microcline, oligoclase, biotite, apatite, titanite, nd magnetite. Sp. gr. 2.672, 27.5°.

B. Same rock and locality as A, but in altered condition. Contains uartz, sericite, chlorite, calcite, pyrite, rutile, etc. Sp. gr. 2.472, 9°.

C. Gabbro, related to diorite, Crœsus mine, Hailey. Contains. bradorite, biotite, diallage, hypersthene, hornblende, quartz, titanite, agnetite, orthoclase, and chlorite. Sp. gr. 2.826, 28°.

D. Same rock and locality as C, but in altered condition. Contains uartz, sericite, chlorite, calcite, pyrite, arsenopyrite, rutile, etc. Sp. r. 2.898, 28°.

Analyses A to D by W. F. Hillebrand, record No. 1826. The metals hich are bracketed with sulphur represent sulphides. Traces of thia are present in all four.

	A.	B.	C.	D.
SiO_2	68.42	71.93	57.78	58.01
Al_2O_3	15.01	12.21	16.28	15.72
Fe_2O_3	.97	.64	1.02	.64
FeO	1.93	2.99	4.92	3.87
MgO	1.21	.58	4.60	2.07
CaO	2.60	2.59	6.65	2.15
Na_2O	3.23	.23	3.25	.10
K_2O	4.25	3.29	2.22	4.79
H_2O at 105°	.54	.37	.34	.31
H_2O above 105°	.73	2.06	.92	2.71
TiO_2	.50	.40	1.07	1.08
P_2O_5	.13	.10	.30	.31
CoO, NiO	none	none	.02	none
MnO	.06	.18	.15	.17
SrO	.03	none	.07	none
BaO	.12	trace	.12	trace ?
CO_2	.20	1.95	.15	2.86
S	.02	.18	.02	1.25
Fe		.13		1.52
Co, Ni		none		.12
Zn		.09		
Pb		trace		.86
Cu		none		.05
As				1.65
	99.95	99.92	99.88	100.24

E. Altered rhyolite, De Lamar mine, Silver City, contains quartz, sericite, pyrite, apatite, and rutile, with some undeterminable magnesian mineral. Analysis by H. N. Stokes, record No. 1731.

F. Altered rhyolite, De Lamar mine. Contains sericite, quartz, kaolinite, and pyrite. Sp. gr., 2.655, 23°.

G. Altered rhyolite, De Lamar mine. Contains quartz, sericite, kaolinite, and pyrite. Sp. gr., 2.576, 24°.

H. Diabasic basalt, Trade Dollar mine, Silver City. Contains labradorite, augite, chlorite, magnetite, secondary quartz, etc.

Analyses F, G, and H by Hillebrand, record No. 1826.

	E.	F.	G.	H.
SiO_2	66.69	87.37	78.59	48.47
Al_2O_3	15.40	7.44	12.13	16.07
Fe_2O_3	1.84	.09	none	4.12
FeO	undet	.18	.09	7.47
MgO	.85	.12	.41	5.96
CaO	.09	.10	.16	4.84
Na_2O	.16	.14	.10	2.43
K_2O	3.50	1.79	2.55	1.41
H_2O at 105°	.83	.51	.82	2.30
H_2O above 105°	2.97	1.39	2.47	4.63
TiO_2	2.11	.09	.12	1.51
P_2O_5	.08	trace	trace	.44
CoO, NiO	....	none	none	trace
MnO	trace	trace?	trace?	.23
SrO	....	none	none	trace
BaO	.09	.02	.02	.03
Li_2O	....	trace	trace	trace
SO_3	.11	....	....	....
FeS_2	3.99	1.00	2.61	.24
Cu	....	....	....	trace
	98.71	100.24	100.07	100.15

Heavy metals not looked for in E.

I. Quartz-monzonite, Schafer Butte, Boise County. Contains quartz, orthoclase, oligoclase, biotite, apatite, titanite, and magnetite. To be described in 20th Ann. Analysis by George Steiger, record No. 1802.

J. Granodiorite, Silver Wreath mine, Boise County. Contains orthoclase, oligoclase, apatite, biotite, titanite, and magnetite. Described in 18th Ann., Part III, p. 642. Sp. gr. 2.714, 23°.

K. Same as J, but in altered condition. Also described in 18th Ann. Contains sericite, quartz, titanite, apatite, and pyrite, with carbonates of calcium, magnesium, and iron. Sp. gr. 2.774, 23°.

Analyses J and K by George Steiger, record No. 1691.

	I.	J.	K.
SiO_2	69.56	65.23	66.66
Al_2O_3	15.29	16.94	14.26
Fe_2O_3	.86	1.60	.67
FeO	2.06	1.91	2.41
MgO	.69	1.31	.95
CaO	2.81	3.85	3.37
Na_2O	3.97	3.57	none
K_2O	3.36	3.02	4.19
H_2O at 100°	.86	.18	.36
H_2O above 100°		.88	2.16
TiO_2	.55	.66	.49
P_2O_5	.16	.19	.17
MnO		trace	trace
BaO		.19	none
S		none	.95
CO_2		.25	3.67
	100.17	99.78	100.31
Less O=S			.24
			100.07

COLORADO.

1. DENVER BASIN.

Rocks described by Cross in Mon. XXVII. Analyses A, B, D, and E by L. G. Eakins, C by W. F. Hillebrand. All but A were made in the Denver laboratory.

A. Dolerite, dike near Valmont. Contains augite, plagioclase, olivine, orthoclase, and biotite, with accessory magnetite and apatite. Record No. 1145. P. R. C. 534.

B. Augite separated from A. P. R. C. 105.

C. Basalt, Table Mountain, lower capping sheet. Contains plagioclase, orthoclase, augite, magnetite, and apatite, with olivine much serpentinized. Sp. gr. 2.83, 22.5°.

D. Basalt, earlier flow, south slope of North Table Mountain. Contains augite, olivine, plagioclase, probably orthoclase, magnetite, apatite, and a little biotite. P. R. C. 535.

E. Augite-mica-syenite, from north fork of Turkey Creek, Jefferson County. Contains orthoclase, augite, biotite, rhombic pyroxene, hornblende, plagioclase, quartz, apatite, and magnetite. Sp. gr. 2.857, 29.5°. P. R. C. 532.

	A.	B.	C.	D.	E.
SiO_2	48.25	49.10	52.59	49.69	56.90
Al_2O_3	16.73	7.95	17.91	18.06	18.50
Fe_2O_3	3.99	....	3.81	2.64	.17
FeO	6.28	8.30	5.18	6.19	4.61
MgO	5.77	12.37	4.11	5.73	5.10
CaO	8.32	22.54	7.24	8.24	6.17
Na_2O	3.24	trace	2.94	2.99	2.99
K_2O	4.08	trace	3.83	3.90	4.14
H_2O	1.72	....	1.24	.91	.51
TiO_2	.89	....	.84	.85	.19
P_2O_5	.68	....	.14	.81	.79
MnO	trace	....	trace	.13	trace
BaO	.01	....	....	....	....
Cl	.08	....	.05	.13	trace
SO_3	.12	....	....	....	....
	100.16	100.26	99.88	100.27	100.07

The following rocks from the Denver Basin were analyzed by L. G. Eakins in the Denver laboratory, but the analyses do not appear in the monograph. The subjoined data have been supplied by Whitman Cross.

A. Enstatite-diabase-porphyry, Mount Morrison. Contains labradorite and enstatite in a groundmass of considerable amount, which is colorless and cryptocrystalline, probably feldspathic, and carries magnetite and other indistinct ferritic matter. P. R. C. 533.

B. Augite-andesite, Table Mountain. Contains plagioclase (andesine), with rare augite and biotite, in a groundmass of plagioclase, augite, magnetite, and minor accessories. This rock contained ptilolite in its vesicular equivalent. Described in Proc. Colorado Sci. Soc., 1886, p. 72.

C. Augite-andesite, a pebble from the Denver beds, Table Mountain. A few augite and andesite phenocrysts in a groundmass of oligoclase, orthoclase, and quartz (?) grains, with some augite and magnetite.

	A.	B.	C.
SiO_2	56.74	59.26	59.29
Al_2O_3	18.80	23.63	21.27
Fe_2O_3	.15	.30	3.33
FeO	6.91	.57	1.04
MgO	5.57	.31	1.12
CaO	7.34	5.93	5.25
Na_2O	2.32	4.94	3.39
K_2O	.77	4.78	3.00
H_2O	1.09	.74	1.63
P_2O_5	.20		.23
MnO	.07		.21
	99.96	100.46	99.76
Sp. gr	2.876, 27°	2.625, 31°	2.596, 14°.5

2. PIKES PEAK DISTRICT.

FIRST GROUP. GRANITE.

Described by E. B. Mathews. Analyses by W. F. Hillebrand, record No. 1470.

A. Granitite, Sentinel Point, western part of Pikes Peak massif. Contains microcline, microcline-perthite, quartz, biotite, a little oligoclase, and accessory fluorite, apatite, zircon, sphene, magnetite, and allanite. P. R. C. 600.

B. Granitite, near road between Florissant and the Platte River. Consists chiefly of microcline in perthitic intergrowth with albite, quartz, and biotite. P. R. C. 606.

C. Porphyritic granitite, south side of Pikes Peak, ridge between Middle and North Beaver creeks. Contains microcline, perthite, orthoclase, oligoclase, quartz, biotite, and accessory apatite, fluorite, zircon, and magnetite. P. R. C. 602.

D. Sheared granite, Currant Creek Canyon, north of Twelvemile Park. Contains perthitic microcline, quartz, muscovite, and sericitic aggregates replacing plagioclase and a part of the microcline. P. R. C. 604.

E. Granite, Currant Creek Canyon, north of Twelvemile Park. Consists chiefly of perthitic microcline, quartz, greenish biotite, muscovite, and plagioclase altered to a sericitic mass. Also flakes of limonite. Accessory minerals rare. P. R. C. 603.

F. Granitite, Middle Beaver Creek, south side of Pikes Peak. Contains microcline, orthoclase, perthitic albite, oligoclase, abundant quartz, biotite, and a little accessory magnetite, fluorite, and zircon. P. R. C. 601.

G. Granite-gneiss, north of Twin Creek. Contains microcline, orthoclase, quartz, biotite, abundant fluorite, and a little sphene and apatite. P. R. C. 605.

	A.	B.	C.	D.	E.	F.	G.
SiO_2	77.03	75.92	75.17	74.40	73.90	73.51	66.90
Al_2O_3	12.00	12.96	12.66	14.43	13.65	13.28	14.86
Fe_2O_3	.76	.33	.23	.89	.28	.94	.93
FeO	.86	1.40	1.40	.22	.42	.97	3.41
MgO	.04	trace	.05	.07	.14	.05	.31
CaO	.80	.15	.82	.58	.23	1.11	1.23
Na_2O	3.21	4.60	2.88	1.76	2.53	3.79	5.56
K_2O	4.92	4.15	5.75	6.56	7.99	5.22	5.02
H_2O at 110°	.14	.16	.16	.15	.16	.16	.16
H_2O above 110°	.30	.32	.66	.92	.33	.62	.31
TiO_2	.13	.05	.10	.12	.07	.18	.43
P_2O_5	trace	trace	.03	.22	.05	trace	.12
MnO	trace	.04	trace	trace	trace	trace	.15
SrO	none	none	trace?	none	none	none	none
BaO	trace	trace	.03	trace	trace	trace	.14
Li_2O	trace	trace	trace	trace	trace	trace	.06
F	.36	.12	.31	.04	none	.55	1.00
CO_2	....	.03	....	....	....	....	....
	100.55	100.23	100.26	100.36	99.75	100.38	100.59
Less O	.15	.05	.13	.02	....	.22	.42
	100.40	100.18	100.13	100.34	....	100.16	100.17

SECOND GROUP. ROCKS OF THE CRIPPLE CREEK DISTRICT.

Described by Cross. Descriptions published, except when otherwise stated, in 16th Ann., Part II, pp. 38–50. Analyses, with two exceptions, which are properly noted, by W. F. Hillebrand, record Nos. 1448, 1453, and 1524.

A. Phonolite, dike in granite northeast of Big Bull Mountain. Contains anorthoclase, nepheline, sodalite, ægirine-augite, some ægirine, biotite, magnetite, and limonite. Nosite not distinguishable. P. R. C. 616.

B. Phonolite, Mitre Peak. Contains sanidine, nepheline, sodalite, ægirine, nosite, and colorless particles which may be låvenite. P. R. C. 608.

C. Phonolite, hill 1 mile south of Straub Mountain. Contains anorthoclase, sanidine, nepheline, sodalite, nosite, analcite, and ægirine, with sometimes ægirine-augite. P. R. C. 612.

D. Phonolite, Rhyolite Mountain. Contains nepheline, nosite, analcite, ægirine, and some ægirine-augite, in a feldspathic groundmass. Sp. gr. 2.52, 23°. P. R. C. 618.

E. Phonolite, between Florissant and Manitou. Analysis by L. G. Eakins, made in the Denver laboratory, inserted here for comparison with the Cripple Creek samples. Described by Cross in Proc. Colorado Sci. Soc., vol. 2, p. 167. Contains sanidine, nepheline, hornblende with accessory pyroxene (?), magnetite, apatite, and sphene. Sp. gr. 2.576, 13°. P. R. C. 637.

F. The portion of E soluble in hydrochloric acid. This portion amounted to 25.39 per cent, and is reduced here to 100. Analysis by Eakins.

	A.	B.	C.	D.	E.	F.
SiO_2	59.00	58.98	58.78	58.64	60.02	44.66
Al_2O_3	20.07	20.54	20.03	19.62	20.98	31.59
Fe_2O_3	1.58	1.65	1.87	2.17	2.21	.95
FeO	.65	.48	.49	.42	.51	
MgO	.10	.11	.16	.37	trace	
CaO	1.05	.67	.83	1.24	1.18	2.25
Na_2O	8.34	9.95	9.36	8.39	8.83	18.42
K_2O	5.63	5.31	5.50	5.26	5.72	2.13
H_2O at 100°	.24	.19	.31	.34	.70	
H_2O above 100°	2.03	.97	1.57	2.40		
TiO_2	.29	.24	.29	.20		
P_2O_5	.05	.04	.03	.03	trace	
ZrO_2	.20	.20	.17	.09		
MnO	.12	.26	.15	.20	trace	
SrO	none	none	none	trace		
BaO	trace	none	none	trace		
Li_2O	trace	trace	trace	trace		
SO_3	.07	.20	.12	trace?		
Cl	.24	.28	.58	.14	trace	
CO_2	.26			.23		
	99.92	100.07	100.24	99.74	100.15	100.00

G. Trachytic phonolite, dike on west slope of Bull Cliff. Contains alkali feldspars, nepheline, nosite, sodalite, augite, scanty ægirine, brown hornblende, magnetite, sphene, apatite, and sometimes låvenite. P. R. C. 624.

H. Altered phonolite, Washington shaft, Victor. Contains potash feldspars, with some alteration to muscovite. Crystals of pyrite and fluorite are visible, but nepheline and ægirine have disappeared. Analysis hitherto unpublished. P. R. C. 623.

I. Nepheline-syenite, near the Longfellow mine. Contains alkali feldspars, nepheline, sodalite, augite, some ægirine, hornblende, biotite, sphene, apatite, and magnetite. Sp. gr. 2.68, 23°. Contains 0.02 V_2O_3.

J. Nepheline-basalt, Appie Ellen shaft. Much altered. Rich in olivine, augite, and magnetite. Also contains nepheline, feldspars in small amount, and biotite. Sp. gr. 2.99, 23°.

K. Altered nepheline-basalt, Anna Lee mine. Analysis hitherto unpublished and not discussed.

L. Local facies of a phonolitic mass, Bull Cliff. Contains abundant augite, plagioclase, alkali feldspar, magnetite, and a little red-brown biotite, with a colorless isotropic base in the darker spots. Analysis hitherto unpublished. P. R. C. 627. Contains 0.03 V_2O_3.

	G.	H.	I.	J.	K.	L.
SiO_2	59.38	56.74	54.34	35.03	48.61	49.84
Al_2O_3	19.47	20.30	19.23	9.80	20.74	17.78
Fe_2O_3	1.60	1.06	3.19	5.55	4.29	5.86
FeO	1.19	....	2.11	4.98	.22	2.62
MgO	.36	.23	1.28	9.78	2.11	3.02
CaO	1.96	.57	4.53	15.09	.25	7.35
Na_2O	7.80	.62	6.38	2.04	.16	5.20
K_2O	5.83	13.36	5.14	2.16	.77	3.04
H_2O at 110°	.11	.33	.14	.41	12.10	.34
H_2O above 110°	.69	1.15	1.17	2.05	7.07	2.02
TiO_2	.58	.58	1.09	2.20	3.57	1.43
P_2O_5	.08	.25	.27	1.99	.29	.76
ZrO_2	.10	.07	.07	none	....	.03
Cr_2O_3	....	....	....	....	trace	....
MnO	.15	none	.08	.06	none	.21
SrO	.03	trace	.16	.17	none	.18
BaO	.13	.19	.24	.14	none	.22
Li_2O	trace	trace	trace	trace	(?)	trace
SO_3	.37	....	.07	none	....	none
Cl	.22	....	.28	trace	....	trace
F	....	undet.	undet.	undet.	.63	undet.
CO_2	....	....	none	7.83	....	.52
FeS_2	....	4.65	....	.38	....	....
	100.05	100.10	99.77	99.66	100.81	100.42

es, hitherto unpublished, except when otherwise stated, by
llebrand, record Nos. 1448, 1453, and 1669. Petrographic data
by Whitman Cross. Names marked with a query are provi-
signations only.

chyte?, near Robbins's ranch. Has scattered phenocrysts of
ldspar, oligoclase, and biotite in a predominant trachytic
ass of alkali feldspar, tridymite, particles of residual glass,
tic flakes and grains.

chyte?, Wicher Mountain. Shows biotite and a few glassy
in a groundmass resembling that of A.

desite?, Bare Hills. Composed mainly of plagioclase and
dspar, with small augites and much ferritic matter. Minute
f a yellowish brown amphibole (?) and scales of tridymite are
le.

roxene-andesite?, Wicher Mountain. Contains phenocrysts of
se, a few of augite, minute specks of iddingsite, and flakes
te. In the groundmass are plagioclase, orthoclase (?), augite,
e, and hypersthene. In the pores tridymite appears. Con-
V_2O_3.

gioclase-basalt?, mesa east of Mac Gulch. Contains plagio-
gite, olivine, iddingsite, magnetite, biotite, and apatite.

gioclase-basalt, Saddle Mountain. Phenocrysts of augite and
a groundmass of plagioclase, orthoclase, augite, magnetite,
nd apatite. Very fresh. See Cross, Journ. Geol., Vol. 5,

	A.	B.	C.	D.	E.	F.
....	69.52	66.12	62.64	57.48	52.97	48.76
....	15.44	17.21	17.82	18.04	18.31	15.89
....	1.90	2.43	3.91	5.73	1.86	6.04
....	.09	trace	.31	.73	6.73	4.56
....	.17	.35	.47	1.17	3.04	5.98
....	1.70	2.11	3.22	5.03	6.51	8.15
....	4.54	4.70	4.47	4.28	3.74	3.43
....	5.04	5.57	4.99	4.15	3.35	2.93
t 100°...	.33	.14	.58	.62	.44	.40
bove 100°	.27	.71	.65	.55	.31	1.48
....	.23	.29	.59	1.00	1.04	1.65
....	.14	.11	.25	.66	.81	.60
....	.05	.06	.08	.04	.05	none
....	.08	.08	.04	trace	.09	.13
....	.04	.05	.07	.12	.14	.06
....	.19	.25	.28	.20	.18	.17
....	....	....	....	.16	....	....
....	.17	....	....	....	....	....
	99.90	100.18	100.37	99.96	99.57	100.23

G. Analcite-basalt, from the Basin. Contains phenocrysts of augite, olivine, and analcite. Also magnetite, with subordinate amounts of alkali feldspars, biotite, and apatite.

H. Portion of the analcite-basalt soluble in hydrochloric acid.

I. Augite separated from G.

J. Analcite separated from G. After deduction of 4.22 per cent of substance insoluble in boiling dilute hydrochloric acid, and later removal of liberated silica with weak potash solution. Sixty-two one hundredths per cent of the water goes off over sulphuric acid. A trace of lithia was found.

The analcite-basalt and its fractions are described by Cross in Journ. Geol., vol. 5, p. 684.

	G.	H.	I.	J.
SiO_2	45.59	44.44	49.26	51.24
Al_2O_3	12.98	[a]20.11	6.01	24.00
Fe_2O_3	4.97	7.50	3.31	1.20
FeO	4.70		4.23	
MgO	8.36	5.81	12.40	.33
CaO	11.09	3.94	21.79	1.62
Na_2O	4.53	8.17	.79	11.61
K_2O	1.04	1.13	.41	1.25
H_2O at 100°	.51	7.91	undet.	9.09
H_2O above 100°	3.40		undet.	
TiO_2	1.32	....	1.53	....
P_2O_5	.91	....	....	....
ZrO_2	.03	....	....	....
MnO	.14	trace	undet.	....
SrO	.12	.16	.06	.06
BaO	.13	(?)	(?)	....
Cl	.05	.10	....	trace
	99.87	99.27	99.79	100.40

[a] Includes P_2O_5 and possible ZrO_2 and TiO_2.

3. SILVER CLIFF AND ROSITA.

Rocks described by Cross, mostly in 17th Ann., Part II, p. 263. Also, partly, in Proc. Colorado Scientific Soc., vol. 2, p. 228. Analyses by L. G. Eakins. Those with record numbers attached were made in the Washington laboratory; all others in the laboratory at Denver.

A. Peridotite, Cottonwood Gulch. Contains hornblende, biotite, hypersthene, olivine, a little plagioclase, apatite, pyrrhotite, and sillimanite (?). P. R. C. 519.

B. Augite-diorite, Mount Fairview, Rosita Hills. Contains augite, biotite, labradorite, and accessory orthoclase, olivine, magnetite, and apatite. Sp. gr. 2.870, 32°. Olivine a subordinate constituent. P. R. C. 526.

C. The same as B, but with orthoclase in much larger amount. Sp. gr. 2.768, 34°. Record No., 1091. P. R. C. 529.

D. Trachyte, Game Ridge. Contains sanidine, plagioclase, a little biotite, magnetite, apatite, and zircon in a groundmass of orthoclase, with a little quartz. Sp. gr., 2.592, 29°. P. R. C. 524.

E. Trachyte, dark-colored dike. Contains more magnetite than D, but otherwise the two are practically identical. Sp. gr. 2.621, 24°.

	A.	B.	C.	D.	E.
SiO_2	46.03	50.47	53.80	66.03	65.41
Al_2O_3	9.27	18.73	20.13	18.49	18.78
Fe_2O_3	2.72	4.19	3.57	2.18	.94
FeO	9.94	4.92	2.63	.22	.72
MgO	25.04	3.48	2.26	.39	.16
CaO	3.53	8.82	5.60	.96	1.58
Na_2O	1.48	4.62	5.20	5.22	5.91
K_2O	.87	3.56	4.49	5.86	5.41
H_2O	.64	.58	.90	.85	1.38
Ti_2O	....	.51	.43	....	....
P_2O_5	.17	.10	.56	.04	trace
MnO	.40	.11	.29	trace	trace
CO_2	....	trace	....	trace	....
Cl	....	trace	....	....	....
	100.09	100.09	99.86	100.24	100.29

F. Andesite, Pringle Hill. Contains plagioclase, orthoclase, quartz, biotite, augite, magnetite, and apatite, with sometimes a little hornblende. Sp. gr. 2.651, 17.8°. Record No. 1124. P. R. C. 528.

G. Pringle andesite, dike. Like F, but often contains sphene. Sp. gr. 2.690, 28°. P. R. C. 527.

H. Bunker andesite, Lookout Mountain. Contains plagioclase, orthoclase, augite, biotite, hornblende, quartz, magnetite, and apatite. Sp. gr. 2.699, 34°. Record No. 1091.

I. Altered Bunker andesite, Robinson Plateau. Biotite gone, magnetite altered to limonite, feldspars not much attacked. Record No. 1124. Sp. gr. 2.580, 19.7°.

J. Much-decomposed Bunker andesite, ridge near Knickerbocker Hill. Augite, hornblende, and biotite all replaced by decomposition products, plagioclase much muscovitized. Record No. 1124. P. R. C. 592.

	F.	G.	H.	I.	J.
SiO_2	58.94	63.49	57.01	63.88	67.13
Al_2O_3	17.19	18.40	18.41	19.96	18.41
Fe_2O_3	2.63	2.44	3.69	2.21	.45
FeO	1.98	1.09	2.36	.57	.07
MgO	1.52	.66	2.34	.58	.44
CaO	4.45	2.30	4.29	2.03	.55
Na_2O	4.20	5.70	4.95	4.19	4.17
K_2O	3.90	4.62	3.72	3.88	5.28
H_2O	4.53	1.04	2.29	2.63	2.98
TiO_2	.27	trace	.27	....	.30
P_2O_5	.23	trace	.42	....	trace
MnO	.10	.16	.21	trace	trace
CO_2	....	trace	....	....	....
	99.94	99.90	99.96	99.93	99.78

K. Dacite, Bald Mountain, near Rosita. Contains plagioclase, biotite, hornblende, sometimes augite, magnetite, and quartz. Sp. gr. 2.574, 24°. Record No. 1068. P. R. C. 530.

L. Mica-dacite. Contains plagioclase, sanidine, biotite, and quartz. Sp. gr. 2.563, 24°. Record No. 1068.

M. Rhyolite, Pennsylvania Hill. Sp. gr. 2.470, 26°. Record No. 1079. P. R. C. 525.

N. Rhyolite, Round Mountain. Contains sanidine, quartz, some glass, and accessory garnet. P. R. C. 521.

O. Rhyolite, Silver Cliff. Sp. gr. 2.560, 15°. Record No. 1125. P. R. C. 522.

	K.	L.	M.	N.	O.
SiO_2	66.46	67.49	70.87	75.20	75.39
Al_2O_3	17.91	17.76	15.18	12.96	13.65
Fe_2O_3	2.42	2.54	2.18	.37	.38
FeO	.35	.08	.12	.27	.18
MgO	.49	.35	.60	.12	.15
CaO	2.89	1.67	1.58	.29	.51
Na_2O	4.79	5.03	3.47	2.02	1.84
K_2O	3.74	4.40	5.04	8.38	6.81
H_2O	1.01	.52	1.08	.58	1.13
TiO_2	....	....	trace	....	trace
P_2O_5	....	trace	trace	trace	trace
MnO	trace	trace	trace	.03	.14
	100.06	99.84	100.12	100.22	100.18

P. Rhyolitic tuff, a lake-bed deposit east of the Blue Mountains. Mainly composed of glassy rhyolite dust.

Q. Devitrified pitchstone, the gangue of ptilolite, 3 miles southeast of Silver Cliff. Shows feldspar, quartz, and barite. Described by Cross and Eakins in Amer. Journ. Sci., 3d series, vol. 44, p. 96. Record No. 1342. P. R. C. 590.

R Pitchstone, Rosita. Record No. 1033. P. R. C. 531.

S. Pitchstone, Fleetwood tunnel, Silver Cliff. P. R. C. 523.

T. Alteration product of S. Consists mainly of silica and kaolin. Record No. of S and T, 1034. P. R. C. 591.

	P.	Q.	R.	S.	T.
SiO_2	71.02	65.67	73.11	71.56	71.71
Al_2O_3	14.27	13.48	13.16	13.10	12.36
Fe_2O_3	1.22	1.51	.62	.66	1.10
FeO			.23	.28	
MgO	trace	.31	.19	.14	1.21
CaO	1.38	2.41	.54	.74	1.11
Na_2O	2.28	1.52	2.85	3.77	.17
K_2O	3.97	2.42	5.10	4.06	.36
H_2O	6.12	12.27	4.05	5.52	11.97
P_2O_5		trace			
MnO		trace	.14	.16	.17
BaO		.32			
SO_3		.28			
	100.26	100.19	99.99	99.99	100.16

U. Syenite, Silver Cliff. Contains orthoclase and plagioclase in nearly equal amounts, colored by ferric hydroxide, with amphibole, a little biotite, and secondary epidote, calcite, and chlorite. Sp. gr. 2.689, 20°. P. R. C. 520.

V. Quartz-alunite rock, Democrat Hill. About two-thirds quartz and one-third alunite. Record No. 1126. P. R. C. 596.

W. The same, Mount Robinson. About one-fourth alunite. Record No. 1248. P. R. C. 593.

X. Quartz-diaspore rock, Mount Robinson. About 18 per cent diaspore, the rest quartz. Record No. 1167. P. R. C. 594.

Rocks V, W, and X are also described in Amer. Journ. Sci., 3d series, vol. 41, p. 471. These three rocks are decomposition products of rhyolite.

	U.	V.	W.	X.
SiO_2	59.78	65.94	69.67	76.22
Al_2O_3	16.86	12.95	13.72	19.45
Fe_2O_3	3.08	.33		trace
FeO	3.72	.07		
MgO	.69	.05	trace	
CaO	2.96	.10	.07	trace
Na_2O	5.39	1.19	.34	trace
K_2O	5.01	2.32	2.44	trace
H_2O	1.58	4.47	4.73	3.82
TiO_2				.11
P_2O_5				.13
MnO	.14	trace		
BaO		trace		
SO_3		12.47	9.27	.29
CO_2	.75			
	99.96	99.89	100.24	100.02

The following analyses, all by L. G. Eakins, do not appear in the published memoir just cited. A and B were made in the Denver laboratory. The petrographic details have been supplied by Whitman Cross.

A. Spherulite in rhyolite, ridge west of Mount Tyndall. Mainly composed of quartz and feldspar needles, with some ferritic coloring due to decomposition of trichites.

B. Rhyolitic residual glass, same locality as A.

C. Interspherulitic mass, Rosita. Record No. 1285.

D. Spherulite, Rosita. Record No. 1286.

E, F, G. Spherulites, Silver Cliff. Record Nos. 1285, 1286.

These spherulites, C, D, E, F, and G, are made up of orthoclase needles, with free silica in fibers or grains, or rarely as tridymite.

The "soluble silica" is that which is dissolved by sodium carbonate solution.

	A.	B.	C.	D.	E.	F.	G.
SiO_2	71.27	85.50	74.47	80.61	83.91	79.21	78.77
Al_2O_3	16.02	7.42	13.87	10.94	9.54	12.24	12.46
Fe_2O_3	1.41	1.23					
FeO	.17	.34					
MgO	trace	.82	trace	.09	trace	.11	.09
CaO	.35	.37	.51	.26	.19	.43	.34
Na_2O	5.76	.74	2.10	2.90	.62	2.58	2.12
K_2O	4.08	2.64	7.46	3.02	5.06	5.26	5.84
H_2O	1.14	1.22	1.88	2.20	.69	.66	.70
P_2O_5	trace	none					
MnO	trace	.08					
	100.20	100.36	100.29	100.02	100.01	100.49	100.32
Soluble SiO_2			12.72	11.12	1.06	1.27	1.25

4. BUFFALO PEAKS.

Hypersthene-andesite, described by Cross in Bull. 1. Contains hypersthene, augite, plagioclase, magnetite, and apatite. Sp. gr. 2.742, 16°. Analyses made by W. F. Hillebrand in the Denver laboratory.

A. Hypersthene-andesite. P. R. C. 588.

B, C, D. Hypersthene separated from the rock. Sp. gr. of D, 3.307, 23°. In B and C alkalies were not tested for. In C and D all the iron is given as FeO.

	A.	B.	C.	D.
SiO_2	56.19	51.70	51.16	50.04
Al_2O_3	16.12	1.72	2.15	2.91
Fe_2O_3	4.92	.30		
FeO	4.43	18.00	18.36	17.81
MgO	4.60	25.09	24.25	21.74
CaO	7.00	2.87	3.81	6.70
Na_2O	2.96			.27
K_2O	2.37			
H_2O	1.03			
P_2O_5	.27			
MnO	trace	.36	.36	.12
SrO	trace			
BaO	trace			
Cl	.02			
	99.91	100.04	100.10	99.59

5. LEADVILLE REGION.

Rocks described by Cross in Mon. XII, Appendix A. Analyses made in the Denver laboratory.

A. Porphyry, Mount Zion. Contains orthoclase, plagioclase, quartz, biotite, apatite, magnetite, and zircon. Analysis by L. G. Eakins. P. R. C. 504.

B. White, or Leadville, porphyry. Contains orthoclase, plagioclase, quartz, muscovite, magnetite, apatite, and zircon, with crystals which appear to be rutile and anatase. Sp. gr. 2.680, 16°. Analysis by W. F. Hillebrand. P. R. C. 587.

C. Porphyry, summit of Mount Lincoln. Contains quartz, orthoclase, plagioclase, biotite, apatite, sphene, magnetite, zircon, and allanite. The sample analyzed showed some muscovite, chlorite, and calcite. Sp. gr. 2.670, 16°. Analysis by W. F. Hillebrand. P. R. C. 505.

	A.	B.	C.
SiO_2	73.50	70.74	66.45
Al_2O_3	14.87	14.68	15.84
Fe_2O_3	.95	.69	2.59
FeO	.42	.58	1.43
MgO	.29	.28	1.21
CaO	2.14	4.12	2.90
Na_2O	3.46	2.29	3.92
K_2O	3.56	2.59	2.89
H_2O	.90	2.09	.84
TiO_2	....	....	.10
P_2O_5	none	....	.36
MnO	.03	.06	.09
SrO	trace	trace	.07
BaO	....	.03	....
Li_2O	....	....	trace
CO_2	....	2.14	1.35
Cl	....	trace	.05
	100.12	100.29	100.09

D. Gray porphyry, Johnson Gulch, near Leadville. Slightly altered. Contains orthoclase, plagioclase, biotite, and quartz, with decomposition products probably derived from original hornblende. Sp. gr. 2.736, 16°. Analysis by Hillebrand.

E. Pink orthoclase crystals from D. Analysis by Hillebrand.

F. Hornblendic porphyrite, lower Buckskin Gulch. Contains plagioclase, orthoclase, quartz, hornblende, biotite, magnetite, apatite, and zircon, with a little secondary calcite and chlorite. Sp. gr. 2.768, 16°. Analysis by Hillebrand. P. R. C. 506.

G. Biotite-porphyrite, dike in gneiss in the North Mosquito amphitheater. Composition like F, but with no horblende, much biotite, and some pyrite. Sp. gr. 2.740, 16°. Analysis by Hillebrand. P. R. C. 507.

	D.	E.	F.	G.
SiO_2	68.10	62.22	56.62	64.81
Al_2O_3	14.97	20.33	16.74	15.73
Fe_2O_3	2.78		4.94	1.68
FeO	1.10		3.27	2.91
MgO	1.10		4.08	2.82
CaO	3.04	2.95	7.39	4.22
Na_2O	3.46	3.45	3.50	3.98
K_2O	2.93	8.31	1.97	1.43
H_2O	1.28	1.90	.92	.62
TiO_2	.07			.08
P_2O_5	.16		trace	.23
MnO	.09		.15	.08
SrO	.08		trace	trace
CO_2	.92		1.15	1.08
Cl	.03			.04
FeS_2				.90
	100.11	99.16	100.73	100.61

H. Rhyolite (nevadite), from Chalk Mountain. Mainly quartz and feldspar, the latter being sanidine and plagioclase. A little biotite, magnetite, apatite, and zircon are present. Analysis by Hillebrand. P. R. C. 64.

I. Sanidine from H. Analysis by Hillebrand. P. R. C. 64.

	H.	I.
SiO_2	74.45	65.04
Al_2O_3	14.72	20.40
Fe_2O_3	none	....
FeO	.56	....
MgO	.37	....
CaO	.83	.79
Na_2O	3.97	4.11
K_2O	4.53	9.74
H_2O	.66	.29
P_2O_5	.01	....
MnO	.28	....
Li_2O	trace	....
	100.38	100.37

6. TENMILE DISTRICT.

Rocks described by Cross in 14th Ann., page 165. Analyses made in the Denver laboratory, A and C by W. F. Hillebrand, B by L. G. Eakins.

A. Quartz-hornblende-mica-porphyrite, Gold Hill. Contains plagioclase, hornblende, biotite, and quartz, in a groundmass of quartz, orthoclase, and a little plagioclase. P. R. C. 510.

B. Quartz-porphyrite, Sugar Loaf. Contains plagioclase, biotite, and quartz, in a groundmass of quartz and orthoclase. P. R. C. 509.

C. Quartz-porphyrite, Chicago Mountain. Contains plagioclase, orthoclase, biotite, and quartz. P. R. C. 508.

	A.	B.	C.
SiO_2	63.66	67.29	68.30
Al_2O_3	17.05	15.78	16.24
Fe_2O_3	1.97	1.86	1.60
FeO	2.62	1.97	1.63
MgO	1.99	.72	1.05
CaO	3.89	2.36	2.79
Na_2O	4.13	3.77	3.90
K_2O	3.09	3.55	3.52
H_2O at 110°	1.19	2.10	.71
H_2O above 110°			
TiO_2	undet.	none	undet.
P_2O_5	.27	.28	.13
MnO	.14	.21	.12
SrO	.08	none	.04
BaO	....	....	trace
Li_2O	none	trace	trace
CO_2	....	.27	....
	100.08	100.16	100.03

The following rocks were also analyzed in the Denver laboratory, but the analyses are hitherto unpublished. Petrographic data furnished by Whitman Cross.

A. Granite-prophyry, McNulty Gulch. Contains phenocrysts of orthoclase, oligoclase, andesine, quartz, biotite, and altered hornblende, in a groundmass of quartz, orthoclase, and magnetite. Accessory sphene, allanite, apatite, and zircon, and a little secondary chlorite are also present. Analysis by W. F. Hillebrand. P. R. C. 586.

B. Granite-porphyry, Jefferson tunnel. Contains orthoclase, oligoclase, quartz, and biotite, in a groundmass of mainly quartz and orthoclase; also accessory magnetite, apatite, zircon, and allanite. Chlorite appears as a decomposition product of biotite, and calcite and magnetite are present in small amounts. Analysis by Hillebrand.

C. Same as B. Analysis by L. G. Eakins. P. R. C. 583.

D. Diorite-porphyry, Copper Mountain. Contains oligoclase, hornblende, and biotite, in a groundmass of quartz, orthoclase, plagioclase, and magnetite; also accessory zircon, sphene, and apatite, and a little secondary chlorite and epidote. Analysis by Eakins. P. R. C. 585.

E. Diorite-porphyry, McNulty type. Contains oligoclase, andesine, hornblende, biotite, and magnetite, in a groundmass of orthoclase, plagioclase, quartz, magnetite, apatite, allanite, and sphene; also secondary chlorite, epidote, and calcite. Analysis by Eakins. P. R. C. 584.

	A.	B.	C.	D.	E.
SiO_2	68.60	65.94	65.51	67.01	63.02
Al_2O_3	16.21	16.00	17.01	18.03	17.61
Fe_2O_3	1.67	.60	none	.66	1.78
FeO	1.57	1.74	2.79	.72	2.76
MgO	1.05	1.02	.90	.84	1.63
CaO	2.61	2.87	3.16	3.99	3.30
Na_2O	3.29	3.85	3.82	4.42	4.72
K_2O	3.88	4.56	4.67	3.53	3.23
H_2O	.92	1.13	1.78	.91	2.03
P_2O_5	.21	.23	.13	.10	.16
MnO	.09	.14	....	.09	trace
SrO	trace	trace	....	....	....
BaO	....	....	....	.10	.08
CO_2	.19	1.55	....	....	....
Cl	.03	.03	trace	....	....
S	....	....	.38	....	....
FeS_2	....	.60	....	....	....
	100.32	100.26	100.15	100.40	100.32
Sp. gr	2.640, 27°	2.672, 21°	2.666, 26°	....	2.689, 16°5

7. ELK MOUNTAINS.

Analyses made by L. G. Eakins in the Denver laboratory, and hitherto unpublished. Petrographic data supplied by Whitman Cross.

A. Rhyolite, East Mountain, Crested Butte district. Phenocrysts of orthoclase, oligoclase, quartz, and biotite, in a microspherulitic and cryptocrystalline groundmass. P. R. C. 514.

B. Rhyolite, Round Mountain, Crested Butte district. Small phenocrysts of quartz, sanidine, biotite, and oligoclase, in a groundmass of quartz and orthoclase. P. R. C. 513.

C. Diorite, Brush Creek, Gunnison County. Contains several varieties of plagioclase, with orthoclase, quartz, hornblende, biotite, augite, sphene, apatite, and magnetite. P. R. C. 93.

	A.	B.	C.
SiO_2	74.84	71.56	62.71
Al_2O_3	14.05	14.91	17.06
Fe_2O_3	.17	1.47	3.79
FeO	.31	1.04	2.74
MgO	trace	.08	1.78
CaO	1.57	1.98	5.51
Na_2O	3.66	3.78	3.54
K_2O	3.14	4.94	2.96
H_2O	2.33	.44	.24
P_2O_5	....	trace	none
MnO	....	....	trace
	100.07	100.20	100.33
Sp. gr	2.38, 17°	2.59, 18°	2.791, 30°

8. WEST ELK MOUNTAINS.

Rocks described by Cross in 14th Ann., p. 165.

A. Hornblende-mica-porphyrite, Cliff Creek. Contains plagioclase, hornblende, and biotite, in a groundmass of quartz, feldspar, and mica. Analysis by W. F. Hillebrand, record No. 1429.

B. Porphyrite, Storm Ridge. Contains plagioclase, biotite, hypersthene, hornblende, and augite, in a groundmass of quartz and orthoclase. Analysis by L. G. Eakins, record No. 1238. P. R. C. 517.

C. Porphyrite-diorite, Mount Marcellina. Contains plagioclase, hornblende, and a little biotite, in a groundmass of quartz and orthoclase. Analysis by T. M. Chatard, record No. 1238. P. R. C. 516.

D. Quartz-porphyrite, Mount Carbon. Contains plagioclase, orthoclase, biotite, hornblende, augite, and quartz. Analysis by Chatard, record No. 1238. P. R. C. 518.

E. Quartz-porphyrite, Crested Butte. Contains plagioclase, orthoclase, hornblende, biotite, quartz, and a little augite. Analysis made by Eakins in the Denver laboratory. P. R. C. 515.

	A.	B.	C.	D.	E.
SiO_2	63.05	61.42	62.85	65.36	65.71
Al_2O_3	15.58	17.69	16.21	15.48	18.30
Fe_2O_3	2.92	4.24	3.08	3.09	1.19
FeO	2.11	1.74	1.46	1.21	1.53
MgO	1.70	1.81	1.47	1.53	.98
CaO	4.15	5.29	4.72	4.14	2.17
Na_2O	3.77	3.14	3.49	3.58	5.00
K_2O	3.66	3.19	3.10	3.41	3.95
H_2O at 100°	.55	.97	.29	.82	1.39
H_2O above 100°	1.38		2.03	.70	
TiO_2	.60	.37	.41	.52	undet.
P_2O_5	.27	.14	.48	.25	....
MnO	.12	.19	.15	.19	.02
SrO	.07	....	....	....	....
BaO	.13	.09	.11	.08	....
Li_2O	trace	....	....	....	....
	100.06	100.28	99.85	100.36	100.24

9. SAN JUAN REGION.

Rocks collected by Whitman Cross, who supplies the petrographic data. Hitherto unpublished.

A. Rhyolitic vitrophyre, near Del Norte, Rio Grande County. Reported by Cross as containing phenocrysts of oligoclase, quartz, biotite, and augite in a dark, fresh, glassy groundmass, the latter being predominant. Analysis made by Eakins in the Denver laboratory. Sp. gr. 2.423, 14°. P. R. C. 598.

B. Rhyolite, Summit district, Rio Grande County. Large phenocrysts of sanidine, with smaller ones of oligoclase and biotite, in a groundmass of orthoclase, quartz, oligoclase, biotite, and magnetite. Analysis by Eakins, made in the Denver laboratory. Sp. gr. 2.489 14°. P. R. C. 164.

C. Augite-diorite, Sultan Mountain, San Juan County. Contains plagioclase, orthoclase, quartz, augite, biotite, magnetite, and apatite. Some chlorite and epidote as alteration products. Analysis by L. G. Eakins in the Denver laboratory. Sp. gr. 2.751, 14°.

D. Augite-diorite, Stony Mountain, Ouray County. Analysis by Eakins in the Denver laboratory. Sp. gr. 2.891, 13.5°. P. R. C. 199.

	A.	B.	C.	D.
SiO_2	68.61	68.85	63.91	52.05
Al_2O_3	16.43	17.01	17.07	17.96
Fe_2O_3	.73	1.78	4.39	4.09
FeO	1.52	.65	1.51	6.33
MgO	.05	trace	.81	5.03
CaO	1.79	1.62	4.47	8.64
Na_2O	2.82	3.44	3.48	2.99
K_2O	4.65	5.11	3.74	1.61
H_2O	3.35	1.79	.33	.97
P_2O_5	....	....	.21	.31
MnO	....	trace	....	.43
	99.95	100.25	99.92	100.41

E. Diorite, La Plata Mountains. Contains augite, hornblende, plagioclase, and orthoclase in large amount, with biotite, quartz, sphene, apatite, and magnetite as subordinate constituents. Also secondary chlorite, muscovite, and calcite. Analysis by W. F. Hillebrand, record No. 1640. Sp. gr. 2.79, 21°.

F. Diorite-porphyry, La Plata Mountains. Contains phenocrysts of hornblende, plagioclase, occasional quartz, sphene, apatite, and magnetite, in a groundmass of orthoclase, plagioclase, and quartz. Also secondary epidote, chlorite, and calcite. Analysis by Hillebrand, record No. 1636. Sp. gr. 2.677, 24°. A trace of sulphur is present.

G. Syenite, between Tirbircio and Schurman gulches, La Plata Mountains. Contains much alkali feldspar, some oligoclase, augite, biotite, and hornblende, with a little titanite, magnetite, and apatite, Analysis by H. N. Stokes, record No. 1764. Sp. gr. 2.704, 25°.

H. Monzonite, Babcock Peak, La Plata Mountains. Contains orthoclase and plagioclase in about equal amounts, with augite and hornblende, and a little quartz, titanite, magnetite, and apatite. Analysis by Stokes, record No. 1764. Sp. gr. 2.767, 26°.

I. Porphyritic lamprophyre, allied to camptonite, Snowstorm Peak, La Plata Mountains. Contains numerous phenocrysts of green hornblende, augite, and plagioclase, in a groundmass of plagioclase, orthoclase, augite, magnetite, and apatite. Some secondary calcite. Analysis by Hillebrand, record No. 1640. Sp. gr. 2.906, 21°.

	E.	F.	G.	H.	I.
SiO_2	55.53	60.44	59.79	57.42	47.25
Al_2O_3	16.78	16.65	17.25	18.48	15.14
Fe_2O_3	4.06	2.31	3.60	3.74	5.05
FeO	3.35	3.09	1.59	2.10	4.95
MgO	3.00	2.18	1.24	1.71	6.87
CaO	6.96	4.22	3.77	6.84	9.98
Na_2O	4.31	5.18	5.04	4.52	2.39
K_2O	3.57	2.71	5.05	3.71	2.60
H_2O at 110°	.09	.36	.19	.08	.40
H_2O above 110°	.55	1.07	.39	.28	2.12
TiO_2	.95	.60	.67	.86	1.22
P_2O_5	.47	.29	.35	.36	.25
V_2O_3	.02	.02			.05
NiO, CoO	trace	none			.02
MnO	.16	.13	.20	.09	.17
SrO	.11	.11	.11	.08	.05
BaO	.13	.12	.14	.15	.08
Li_2O	trace	trace	trace	trace	[illegible]
CO_2	.09	.48	.72	none	1.87
SO_3			.04	none	
Cl			trace	.03	
FeS_2	.04				none
	100.17	99.96	100.14	100.45	100.46

J. Porphyritic lamprophyre, allied to camptonite, Indian Trail Ridge, La Plata quadrangle. Contains phenocrysts of green hornblende and colorless dioxide in a subordinate groundmass of plagioclase, orthoclase (?), augite, magnetite, and apatite. Much secondary calcite and some serpentine. Analysis by W. F. Hillebrand, record No. Sp. gr. 2.912, 19.5°.

K. Lamprophyre, allied to camptonite, Black Face, Telluride quadrangle. Consists of a fine felt of plagioclase, augite, and brown hornblende microlites, with flakes of biotite, and a cryptocrystalline part, which is probably in large degree orthoclase. Some magnetite and apatite. Analysis by Hillebrand, record No. 1719. Sp. gr. 2.783, 22°.

L. Quartz monzonite, northeast of San Miguel Peak, Telluride quadrangle. Contains orthoclase and plagioclase in about equal amounts, with abundant quartz and much less augite, hornblende, biotite, magnetite, and apatite. Analysis by H. N. Stokes, record No. 1764. Sp. gr. 2.720, 34°.

M. Gabbroitic facies of a diorite-monzonite stock, Ophir Needles, Telluride quadrangle. Contains abundant labradorite, with augite, hypersthene, biotite, orthoclase, magnetite, apatite, and a very little quartz. Analysis by Stokes, record No. 1764. Sp. gr. 2.860, 33°.

N. Gabbro-porphyry, pass south of Mount Sneffels, Telluride quadrangle. Contains numerous phenocrysts of labradorite or bytownite, in a groundmass of plagioclase, orthoclase (?), augite, hypersthene, biotite, magnetite, and apatite. Analysis by Stokes, record No. 1764. Sp. gr. 2.949, 26.5°.

	J.	K.	L.	M.	N.
SiO_2	43.98	55.65	65.70	56.93	47.32
Al_2O_3	13.30	17.04	15.31	17.03	16.71
Fe_2O_3	3.67	2.81	2.54	3.67	6.92
FeO	6.92	5.17	1.62	4.54	5.94
MgO	7.03	3.42	1.62	3.30	5.69
CaO	10.66	6.82	2.56	6.51	8.51
Na_2O	2.15	3.27	3.62	3.19	2.70
K_2O	1.64	2.29	4.62	2.58	2.02
H_2O at 110°	.42	.46	.17	.13	.24
H_2O above 110°	1.52	1.49	.42	.45	1.04
TiO_2	1.18	.90	.72	1.03	1.50
P_2O_5	.32	.37	.33	.44	.96
MnO	.22	.20	trace	.10	.08
NiO, CoO	.03	none			
SrO	.05	.05	.03	.06	.06
BaO	.06	.08	.12	.08	.07
Li_2O	trace	trace	trace	none	trace
CO_2	6.46		none	none	none
SO_3		none	.12	none	.19
Cl			.03	trace	trace
FeS_2	.54				
	100.15	100.02	99.53	100.04	99.95

10. MISCELLANEOUS ROCKS.

A. Rhyolite, east bank of Arkansas River, Nathrop. Described by Cross in Proc. Colorado Sci. Soc., vol. 2, p. 69. Contains quartz and sanidine in a groundmass mainly of quartz and alkali feldspar. This rock carries topaz and spessartite in its lithophysae. Analysis made by L. G. Eakins in the Denver laboratory. Sp. gr. 2.602, 29°.

B. Granite, Platte Canyon. Described by E. B. Mathews in Bull. 150, p. 172. Contains microcline, quartz, biotite, oligoclase, and fluorite. Apatite, zircon, magnetite, hematite, limonite, epidote, and rutile (?) are sometimes present. Analysis by H. N. Stokes, record No. 1314.

C. Hornblende-porphyrite, Hermano Peak, Sierra El Late. Described by Cross in 14th Ann., p. 165. Contains plagioclase, hornblende, rare quartz, and a little biotite. Analysis by W. F. Hillebrand, record No. 1429.

D. Hornblende-porphyrite, Ute Peak, Sierra El Late. Described by Cross in 14th Ann., p. 165. Contains plagioclase, hornblende, and very little augite, in a groundmass of quartz, orthoclase, and plagioclase. Analysis by Hillebrand, No. 1429.

E. Porphyritic augite-diorite, Lone Cone, San Miguel Mountains. Described by Cross in 14th Ann., p. 165. Contains plagioclase, augite, hornblende, and biotite, in a groundmass of quartz, orthoclase, and plagioclase. Inclusions of magnetite and apatite in the augite. Analysis by Hillebrand, No. 1429.

	A.	B.	C.	D.	E.
SiO_2	69.89	77.02	62.65	59.42	59.19
Al_2O_3	17.94	11.63	16.68	16.79	18.00
Fe_2O_3	.39	.32	2.35	3.23	3.07
FeO	.52	1.09	2.63	3.29	2.32
MgO	.14	.14	1.43	2.24	1.41
CaO	trace	1.24	4.96	5.57	6.55
Na_2O	4.21	2.85	4.45	4.15	4.01
K_2O	4.38	5.21	2.75	2.82	2.74
H_2O at 100°	2.07	.35	.27	.27	.46
H_2O above 100°			.66	.79	1.06
TiO_2			.42	.68	.58
P_2O_5	trace		.28	.35	.29
MnO	.23	trace	.16	.13	.19
SrO			.11	.07	.13
BaO			.13	.14	.18
Li_2O	trace		trace	trace	trace
CO_2				.44	
	99.77	99.85	99.93	100.38	100.18

F. Tinguaite?, Two Buttes. Collected by G. K. Gilbert; petrographic data supplied by Whitman Cross. Consists chiefly of pale-green augite, hornblende, apatite, magnetite, and occasional crystals of alkali feldspar, in an obscure, largely isotropic groundmass. Sp. gr., 2.79, 25°.

G. Pyroxene from F. Sp. gr., 3.43, 28°.

H. Portion of F soluble in $\frac{1}{10}$ nitric acid.

I. Syenitic lamprophyre?, Two Buttes. Collected by Gilbert; description by Cross. Chief constituents, diopside, alkali feldspar, considerable biotite, magnetite, and olivine. The ferromagnesian minerals predominate. Sp. gr., 2.88, 29°. Also contains 0.03 V_2O_3.

J. Pyroxene from I. Sp. gr., 3.45, 25°.

K. Portion of I soluble in $\frac{1}{10}$ nitric acid.

Analyses F to K by W. F. Hillebrand, record No. 1604.

	F.	G.	H.	I.	J.	K.
SiO_2	47.61	47.54	13.27	50.41	51.27	1.58
Al_2O_3	14.26	4.14	9.40	12.30	3.05	1.00
Fe_2O_3	4.90	5.64	....	5.71	3.08	none
FeO	4.07	6.42	trace	3.06	4.34	.87
MgO	2.62	10.05	trace	8.69	14.21	1.22
CaO	8.71	21.57	1.70	7.08	22.58	.68
Na_2O	6.70	1.38	5.41	.97	.67	undet.
K_2O	4.08	.12	.66	7.53	.06	undet.
H_2O at 110°	.26	none	undet.	.46	none	none
H_2O above 110°	1.89	undet.	undet.	1.80	undet.	undet.
TiO_2	1.38	3.00	....	1.47	.70	....
P_2O_5	1.38	....	1.34	.46	....	.46
ZrO_2	.18	none	....	none	none	....
Cr_2O_3	trace?	trace?	....	trace	none	....
NiO	trace	trace	....	.04	.03	....
MnO	.30	.36	trace	.15	.28	trace
SrO	.36	none	.11	.06	none	(?)
BaO	.41	none	none	.23	none	none
Li_2O	trace	trace	(?)	trace	....	....
SO_3	1.17	....	.77	none	....	....
S	.03	....	.03	none	....	....
Cl	.37	....	.37	trace	....	trace
F	trace	....	trace	trace?	....	....
	100.68	100.21	33.06	100.42	100.27	5.81

UTAH.

I. ROCKS FROM THE TINTIC DISTRICT.

Described by Tower and Smith in 19th Ann., Part III, pp. 609 et seq. Analyses by Stokes, record No. 1746.

A. Gray, porphyritic rhyolite, south of Pinyon Creek. Contains phenocrysts of sanidine, quartz, biotite, plagioclase, and hornblende; the last mineral sparingly. Also tridymite, magnetite, apatite, zircon, and a small amount of glassy residue.

B. Quartz-porphyry, Swansea mine. Phenocrysts of feldspar and quartz, the orthoclase somewhat altered. Microscopic biotite occurs sparingly. Also contains magnetite, apatite, zircon, a little chlorite, and secondary pyrite.

C. Andesite, Tintic Mountain. Phenocrysts of biotite and feldspar. Contains plagioclase, chiefly labradorite, augite, biotite, hypersthene, magnetite, and apatite, in a dark-gray glass.

D. Granular monzonite, Iron Duke mine. Contains orthoclase, plagioclase, quartz, hornblende, biotite, magnetite, apatite, zircon, and titanite, with a little chlorite and epidote.

E. Altered monzonite, near Tintic mine. Feldspar and ferromagnesian minerals completely altered. Rutile is present; quartz seems to have been added.

	A.	B.	C.	D.	E.
SiO_2	69.18	71.56	60.17	59.76	71.14
Al_2O_3	14.36	14.27	15.77	15.77	16.22
Fe_2O_3	2.52	.89	3.42	3.77	.94
FeO	.57		2.95	3.30	.16
MgO	.70	.42	2.52	2.16	1.12
CaO	1.88	1.18	4.69	3.88	.25
Na_2O	3.58	3.00	2.96	3.01	.07
K_2O	5.00	4.37	4.16	4.40	4.96
H_2O at 110°	.35	.36	.25	.31	.49
H_2O above 110°	.25	.79	1.23	1.11	2.74
TiO_2	.69	.38	.87	.87	.75
P_2O_5	.26	.13	.40	.42	.32
Cr_2O_3	trace	trace	none	none	none
V_2O_3	.01	.01	.01	.02	.02
MnO	.10	trace	.11	.12	trace
BaO	.09	.28	.14	.09	.05
SrO	trace	trace	.09	trace	trace
Li_2O	trace	none	trace	trace	trace
CO_2	none	none	none	.78	none
S	none	....	none	none	....
SO_3	none	....	none	none	.26
FeS_2	....	2.29	....	....	....
Cl	trace	.06	.04	.04	trace
	99.54	99.99	99.78	99.81	99.49

Fluorine was not looked for in the analyses.

2. ROCKS FROM THE HENRY MOUNTAINS.

A. Porphyry. Not hitherto published. Reported by J. S. Diller as containing prominent plagioclase with some augite and hornblende in a crystalline groundmass of quartz and orthoclase. Analysis by R. B. Riggs, record No. 728.

B. Augite-porphyrite, dike, north spur of Mount Pennell. Contains hornblende, augite, and plagioclase in a feldspathic groundmass.

C. Hornblende-porphyrite, Mount Hillers. Contains plagioclase, hornblende, quartz, and magnetite.

Analyses B and C by W. F. Hillebrand, record No. 1428. Rocks described by Cross in 14th Ann., p. 165.

	A.	B.	C.
SiO_2	63.16	60.98	62.88
Al_2O_3	17.21	19.09	17.13
Fe_2O_3	2.43	1.76	1.86
FeO	2.30	1.15	2.58
MgO	1.27	.65	1.48
CaO	6.27	3.67	5.39
Na_2O	4.70	6.70	4.50
K_2O	1.84	3.53	2.25
H_2O at 100°	....	.48	.16
H_2O above 100°	.69	.44	.42
TiO_2	.21	.36	.51
P_2O_5	.12	.10	.26
MnO	trace	.15	.16
SrO	trace?	.28	.12
BaO	.09	.43	.16
Li_2O	trace	trace	trace
CO_2	....	.52	....
SO_3	trace	....	....
	100.29	100.29	99.86

3. MISCELLANEOUS ROCKS.

A. Rhyolite, Thomas Range. Analysis made by L. G. Eakins in the Denver laboratory. Described by Cross in Proc. Colo. Sci. Soc., vol. 2, p. 69. Contains phenocrysts of quartz and sanidine in a groundmass mainly made up of quartz and alkali feldspar.

B. Rhyolitic glass or pitchstone, edge of Gold Mountain mining district, 8 miles north of west from Marysvale. Identified by Whitman Cross, but not published. Sp. gr. 2.25 at 23.5°. Analysis by W. F. Hillebrand, record No. 1833.

	A.	B.
SiO_2	74.49	70.17
Al_2O_3	14.51	11.83
Fe_2O_3	.57	.93
FeO	.32	none
MgO	trace	.06
CaO	1.03	.76
Na_2O	3.79	3.85
K_2O	4.64	3.74
H_2O	.64	8.72
TiO_2	....	.17
MnO	trace	....
Li_2O	trace	....
	99.99	100.23

NEW MEXICO.

1. BASALTS FROM RIO GRANDE CANYON.

Described by Iddings, Bull. 66; also in Amer. Journ. Sci., 3d series, ol. 36, p. 220. Contain plagioclase, augite, olivine, and magnetite. ., B, and C contain quartz also; D is quartzless. Analyses by L. G. akins, record Nos. 847, 850.

A. Light gray, dense. P. R. C. 548.
B. Greenish black, dense.
C. Dark red, vesicular. P. R. C. 549.
D. Gray dense. P. R. C. 547.

	A.	B.	C.	D.
SiO_2	52.27	52.37	51.57	52.38
Al_2O_3	17.68	17.01	17.72	18.79
Fe_2O_3	2.51	1.44	6.24	2.88
FeO	5.00	5.89	1.78	4.90
MgO	6.05	6.86	4.91	4.91
CaO	8.39	7.59	8.82	7.70
Na_2O	4.19	3.51	3.59	3.99
K_2O	1.58	1.59	1.99	1.76
H_2O	.82	1.29	.64	.53
TiO_2	1.49	1.60	1.43	1.22
P_2O_5	....	....	....	.56
MnO	.23	.32	.45	.18
BaO	.06	.06	.16	.11
CO_2	trace	.37	.58	....
Cl	trace	trace	....	....
	100.27	99.90	99.88	99.91

2. MOUNT TAYLOR REGION.

Rocks received from J. S. Diller. Analyses by T. M. Chatard, record Nos. 219, 227, 228, 235, 271, 268, and 269. Not hitherto published. Petrographic details furnished by Diller.

A. Lava, canyon on east side of San Mateo Mountain.

B. Phonolitic andesite, canyon on east side of San Mateo Mountain. Contains feldspar and corroded augite, with sometimes olivine, in a groundmass of feldspar and a green ferromagnesian silicate.

C. Mica-andesite, canyon on east side of San Mateo Mountain. Shows prominent plagioclase, with augite and biotite.

D. Mica-andesite, 6 miles northeast of Grant's. Principally plagioclase and biotite, with less epidote, quartz, sphene, and carbonates.

E. Basalt, 6 miles northeast of Grant's. Contains chiefly plagioclase, augite, and olivine, with much magnetite.

F. Augite from E.

G. Feldspar from E. Analysis on three-fourths gramme of material.

	A.	B.	C.	D.	E.	F.	G.
SiO_2	68.40	65.51	65.78	49.80	47.54	47.06	52.54
Al_2O_3	17.99	16.89	17.32	15.33	16.73	7.77	31.26
Fe_2O_3	2.66	1.41	3.68	....	6.69	1.30	....
FeO	1.63	2.52	.46	7.44	6.67	8.15	....
MgO	.49	.39	.47	6.61	6.38	13.52	.28
CaO	.67	1.19	1.66	7.19	8.74	19.33	12.34
Na_2O	4.54	6.42	5.23	2.71	2.81	.33	3.55
K_2O	3.54	5.02	4.64	4.36	1.10	.11	.42
H_2O	.52	.16	.14	1.38	.36	.20	.26
TiO_2	....	.92	.27	2.67	2.76	1.82	undet.
P_2O_5	....	.07	.13	.73	.51	.06	....
Cr_2O_3	....	....	....	....	....	trace	....
MnO	.21	.31	.32	.30	.19	.20	....
(CoNi) O	....	....	....	....	....	traces	....
BaO	....	....	....	....	.03	....	trace ?
CO_2	....	....	....	2.56	(?)	....	....
	100.65	100.81	100.10	101.08	100.51	99.85	100.65

3. COLFAX COUNTY.

Descriptions, hitherto unpublished, supplied by Whitman Cross. Analyses by W. F. Hillebrand, record No. 1719.

A. Phonolite, Pleasant Valley. Contains much nephelite, some ægirite, alkali feldspar, a scanty dust of magnetite, and a few decomposed grains of noselite or sodelite. Sp. gr. 2.619, 22°; 40.8 per cent soluble in dilute (1:40) nitric acid, of which soluble portion 43.5 per cent is silica.

B. Pyroxene-andesite, Sierra Grande. Contains augite, less hypersthene, microliths of plagioclase, apatite, magnetite, and a smoky-brown glassy base. Sp. gr. 2.635, 21°.

C. Plagioclase-basalt, end of San Rafael flow. Contains plagioclase, augite, olivine, with much iddingsite, magnetite, and apatite. Sp. gr. 2.970, 21.5°.

D. Nepheline-basanite, Ciruella. Contains augite, olivine, nephelite, plagioclase, magnetite, apatite, and a little biotite. Sp. gr. 3.122, 22°. 0.55 per cent K_2O and 2.10 per cent Na_2O soluble in 1:40 nitric acid.

	A.	B.	C.	D.
SiO_2	56.24	60.16	48.35	42.35
Al_2O_3	21.43	15.34	15.47	12.29
Fe_2O_3	2.01	3.07	4.80	3.89
FeO	.55	2.18	7.58	7.05
MgO	.15	3.41	8.15	13.09
CaO	1.38	5.79	8.81	12.49
Na_2O	10.53	3.88	3.09	2.74
K_2O	5.74	2.59	.95	1.04
H_2O at 110°	.12	.25	.28	.32
H_2O above 110°	.86	1.79	.73	1.50
TiO_2	.26	.84	1.33	1.82
P_2O_5	.06	.46	.33	.99
ZrO_2	.09	.01	none	none
Cr_2O_3	none	trace?	trace	.10
V_2O_3	....	....	....	.04
NiO, CoO	none	trace	.02	.03
MnO	.08	.08	.21	.21
SrO	.03	.08	.03	.09
BaO	.08	.14	.06	.10
Li_2O	trace	trace	trace	trace
SO_3	.10	.08	.07	.05
S	.03	trace	trace	trace
Cl	.12	undet.	undet.	undet.
F	trace	undet.	undet.	undet.
	99.86	100.15	100.26	100.19

4. MISCELLANEOUS ROCKS.

A. Obsidian, Obsidian Hill camp, Tewan Mountains. Described by Iddings, 7th Ann., p. 292. A rhyolitic obsidian, containing grains of iron oxide and a few microscopic feldspars. Resembles that from Obsidian Cliff in the Yellowstone National Park. Analysis by L. G. Eakins, record No. 851. Sp. gr., 2,352, 23°.5.

B. Trachyte (?), from Los Cerillos. Described by Diller, Bull. 42, p. 39. Analysis by F. W. Clarke, record No. 346. Rock composed chiefly of orthoclase, with a considerable amount of biotite, epidote, pyrite, and limonite, and some amorphous substance. It is the matrix or gangue rock of the Los Cerillos turquois.

	A.	B.
SiO_2	76.20	56.68
Al_2O_3	13.17	16.62
Fe_2O_3	.34	6.28
FeO	.73	....
MgO	.19	.79
CaO	.42	.59
Na_2O	4.31	1.03
K_2O	4.46	11.18
H_2O	.33	3.28
TiO_2	trace	.22
P_2O_5	....	.73
FeS_2	....	2.21
MnO	.10	1.02
CuO	....	trace
	100.25	100.63

ARIZONA.

A, B, C, D. Mica-basalt, Santa Maria Basin. See Iddings, Bull. Phil. Soc. Washington, vol. 12, p. 212. Not fully described. Analyses by W. F. Hillebrand, record No. 1261.

E. Hornblende-porphyrite, Sierra Carrizo. Described by Cross, 14th Ann., p. 165. Contains plagioclase and hornblende, in a groundmass of quartz and orthoclase. Analysis by Hillebrand, No. 1429.

	A.	B.	C.	D.	E.
SiO_2	49.36	55.35	57.04	57.48	63.18
Al_2O_3	16.35	12.91	13.66	14.09	16.47
Fe_2O_3	2.93	4.67	4.96	5.21	2.36
FeO	8.55	2.06	1.77	1.35	2.28
MgO	7.06	6.29	4.43	3.49	1.33
CaO	10.08	5.77	6.23	6.05	4.77
Na_2O	2.67	2.65	3.08	3.00	4.40
K_2O	.82	4.86	4.95	4.69	2.93
H_2O at 100°	.22	2.67	1.11	1.20	.27
H_2O above 100°	.65	1.18	1.10	1.37	.60
TiO_2	.98	.87	.94	.94	.60
P_2O_5	.30	.58	.63	.65	.28
MnO	.19	.08	.17	.09	.15
NiO, CoO	.05	.05	.07	.08	....
SrO	none	trace	trace	trace	.09
BaO	.04	.19	.22	.23	.15
Li_2O	none	trace	trace?	none	trace
	100.25	99.98	100.36	99.92	99.86

F. Typical hypersthene-andesite, San Francisco Mountains. Not described. Analysis by T. M. Chatard, record No. 270.

G. Recent lava, 2 miles south of Mount Trumbull. Not described. Analysis by L. G. Eakins, record No. 1024.

	F.	G.
SiO_2	64.82	45.30
Al_2O_3	18.27	14.95
Fe_2O_3	3.48	1.98
FeO	.56	9.32
MgO	.85	8.29
CaO	2.89	8.87
Na_2O	5.05	4.27
K_2O	2.67	1.27
H_2O	.20	.85
TiO_2	.56	2.66
P_2O_5	.23	2.23
MnO	.20	trace
	99.78	99.99

NEVADA.

1. ROCKS FROM WASHOE.

Described by Hague and Iddings, Bull. 17. Analyses by F. A. Gooch, record Nos. 119, 129. FeO not separately determined.

A. Rhyolite, south-southeast of McClellan Peak. Contains feldspars, orthoclase predominating over plagioclase, quartz, mica, and hornblende.

B. Dacite, spur northeast of McClellan Peak. More plagioclase than orthoclase, much mica, less hornblende, little quartz.

	A.	B.
SiO_2	73.07	69.96
Al_2O_3	11.78	15.79
Fe_2O_3	2.30	2.50
MgO	.39	.64
CaO	2.02	1.73
Na_2O	1.19	3.80
K_2O	6.84	4.12
Ignition	2.24	1.53
	99.83	100.07

2. ROCKS FROM EUREKA.

Described by Hague and Iddings, Mon. XX.

A. Basalt, summit of Richmond Mountain. Red, porous. Contains augite, less hypersthene, feldspars, and magnetite, in a glassy base, with accessory olivine and quartz. Analysis by J. E. Whitfield, record No. 424.

B. Andesitic perlite, south of Carbon Ridge. Contains plagioclase, hornblende, biotite, quartz, hypersthene, augite, magnetite, apatite, and zircon, with a glassy base. Analysis by W. H. Melville, record No. 1240.

	A.	B.
SiO_2	50.38	65.13
Al_2O_3	19.83	15.73
Fe_2O_3	6.05	2.24
FeO	2.00	1.86
MgO	5.36	1.49
CaO	10.03	3.62
Na_2O	2.15	2.93
K_2O	1.76	3.96
H_2O at 105°	1.37	.52
H_2O above 105°		1.91
TiO_2	none	.58
P_2O_5	none	.23
NiO	....	.07
MnO	.38	trace
Li_2O	trace	....
SO_3	.83	....
	100.14	100.27

CALIFORNIA.

1. MOUNT SHASTA.

Description of rocks furnished by J. S. Diller, who also describes A, B, and C in Bull. 150, pp. 221, 227.

A. Hornblende-andesite, Black Butte, west base of Shasta. Contains plagioclase and hornblende in a microlitic groundmass. The latter carries hypersthene, magnetite, and amorphous matter. Analysis by W. H. Melville, record No. 1346. P. R. C. 84.

B. Hypersthene-andesite, older flow, west base of Shasta. Contains plagioclase, hypersthene, magnetite, and glass. Analysis by Melville, No. 1346.

C. Hypersthene-andesite, like B, same locality, later flow. Analysis by Melville, No. 1346. P. R. C. 87.

D. Hornblende-andesite, late flow, eastern side of Shasta. Contains small crystals of plagioclase and hornblende in a dark groundmass. Thin section not examined. Analysis by H. N. Stokes, record No. 1532.

E. Ophitic basalt from near the McCloud River, south of Mount Shasta. A gray cellular rock. Thin section not examined. Analysis by Stokes, No. 1532.

F. Andesite basalt, Delta, Shasta County. Much plagioclase and a few hypersthene crystals in a groundmass chiefly of feldspar, pyroxene, magnetite, and trace of olivine. Analysis by Melville, No. 1346.

	A.	B.	C.	D.	E.	F.
Si_2O	64.48	64.52	63.03	61.58	47.94	55.08
Al_2O_3	19.28	18.31	17.72	16.96	18.90	18.93
Fe_2O_3	1.40	.90	2.27	1.75	2.21	2.02
FeO	1.78	2.51	1.92	2.85	8.59	5.56
MgO	1.64	2.35	3.63	3.67	8.21	5.17
CaO	5.06	5.11	5.97	6.28	9.86	8.40
Na_2O	4.41	4.64	3.92	3.94	2.81	4.23
K_2O	1.12	1.25	1.06	1.28	.29	.74
H_2O at 110°	.06	.20	.44	.24	.39	.29
H_2O above 110°				1.06	.74	
TiO_2	undet.	undet.	undet.	.49	.57	trace
P_2O_5				.22	.15	
MnO				trace	trace	
SrO				trace	none	
BaO				.03	none	
Li_2O				trace	trace	
	99.23	99.79	99.96	100.35	100.66	100.42

The following rocks are from Shasta County, but not within either the Mount Shasta or the Lassen Peak areas. Collected by J. S. Diller, who furnishes the petrographic data.

A. Dacite-porphyry, east fork of Clear Creek, 9 miles above French Gulch. Contains conspicuous phenocrysts of plagioclase, a few of quartz, and smaller ones of biotite and pyroxene, in a groundmass of quartz and feldspar. Analysis by J. E. Whitfield, record No. 970.

B. Dacite-porphyry, Smiths Gulch, 6 miles up Clear Creek from French Gulch. Contains phenocrysts of plagioclase, quartz, biotite, and hornblende, in a groundmass chiefly of quartz and feldspar. Analysis by Whitfield, No. 971. Also described by J. P. Iddings in Bull. 150, p. 233. P. R. C. 90.

C. Diorite, from Ono. Not described. Analysis by T. M. Chatard, record No. 1107.

	A.	B.	C.
SiO_2	66.30	64.24	68.10
Al_2O_3	17.55	18.67	15.18
Fe_2O_3	2.19	1.40	1.34
FeO	.55	1.96	1.70
MgO	.97	1.48	2.06
CaO	3.12	4.11	4.66
Na_2O	5.15	4.14	3.71
K_2O	2.45	1.71	1.48
H_2O	1.25	1.18	.55
TiO_2	trace	.76	.35
P_2O_5	.15	.08	.18
MnO	trace	trace	.20
BaO	....	....	.06
SO_3	.28	.22	....
Cl	....	.25	....
	99.96	100.20	99.57
Less O	....	.05	
		100.15	

2. LASSEN PEAK REGION.

Rocks collected by J. S. Diller, who has furnished the petrographic data. Nearly all are from the area covered by the Lassen Peak atlas sheet of the U. S. Geological Survey. The quartz basalts have been described by Diller in Bull. 79, and partly in Amer. Journ. Sci., 3d series, vol. 33, p. 49. The analyses are so numerous that it seems best to divide them into subordinate groups.

1st. RHYOLITES.

A. Rhyolite, a short distance northwest of Willow Lake, near the Geyser, Plumas County. A light-gray rock with occasional phenocrysts of quartz and feldspar in a granular groundmass of the same materials. Analysis by W. F. Hillebrand, record No. 414.

B. Rhyolite, 2 miles northwest of Deer Creek Meadows, Tehama County. Shows many small crystals of quartz, feldspar, and biotite in a spherulitic groundmass. Analysis by Hillebrand, No. 415.

C. Rhyolite, Slate Creek, west of Deer Creek Meadows. Composed wholly of spherulites, some of which include crystals of feldspar or biotite. Analysis by Hillebrand, No. 416.

D. Rhyolite, summit of Mount Stover, Plumas County. Composed almost wholly of spherulites, with a few crystals of feldspar and hornblende. Analysis by Hillebrand, No. 417.

E. Rhyolite, near Slate Creek, west of Deer Creek Meadows. A pearlite, composed chiefly of little glass balls, with a few spherulites, and crystals of feldspar and biotite. Analysis by Hillebrand, No. 418.

F. Rhyolite, 1½ miles northeast of Clipper Mills, on tramway to Rock Creek, Shasta County. A spherulitic rock containing a few microscopic particles of feldspar and hornblende. Analysis by Hillebrand, No. 678.

G. Rhyolite-tuff, divide between the west fork of Willards Creek and the stage road, in Lassen County. Elevation, 5,800 feet. Composed almost wholly of fine angular particles of clear glass. Analysis by George Steiger, record No. 1427.

Materials for A to F dried at 110° previous to analysis.

	A.	B.	C.	D.	E.	F.	G.
SiO_2	74.24	74.65	73.62	72.40	73.64	74.60	70.01
Al_2O_3	14.50	14.11	14.24	14.81	13.44	13.41	12.61
Fe_2O_3	1.27	1.08	.93	.81	.60	1.28	1.47
FeO	.67	.29	.67	.88	.74	.30	.50
MgO	.25	.20	.33	.47	.26	.26	.72
CaO	.11	.80	1.07	1.94	1.26	1.08	1.06
Na_2O	3.00	2.81	3.25	3.91	3.51	3.38	1.94
K_2O	3.66	4.59	4.28	3.90	4.50	4.50	5.12
H_2O at 100°	....	....	....	....	....	....	2.37
H_2O above 100°	2.04	1.40	1.29	.59	1.99	.85	4.68
TiO_2	.20	.21	.21	.18	.11	.16	....
P_2O_5	.07	trace	.02	.03	.06	.03	.04
MnO	.06	.11	.08	.07	.06	.06	trace
SrO	trace	trace	trace	.04	.02	none	....
BaO	.18	.08	.10	.10	.11	.11	....
Li_2O	none	none	none	trace	trace	trace	....
SO_3	.03	....	....	....	....	....	....
	100.28	100.33	100.09	100.13	100.30	100.02	100.52

2D DACITES AND ANDESITES.

A. Gray dacite, Lassen Peak. Contains hornblende, biotite, plagioclase, quartz, scarce pyroxene, magnetite, apatite, and a glassy base. Analysis by T. M. Chatard, record No. 111. P. R. C. 82.

B. Secretion in dacite, Lassen Peak. Composed chiefly of plagioclase and hornblende. Analysis by Chatard, No. 110.

C. Reddish dacite, Lassen Peak. Essentially like A. Analysis by Chatard, No. 110. P. R. C. 82.

D. Dacite, near the timber line, west base of Lassen Peak. Small phenocrysts of plagioclase and hornblende, with a few of quartz, in a reddish-gray groundmass containing much amorphous matter. Analysis by W. F. Hillebrand, record No. 668. P. R. C. 82.

E. Secretion in D. Composed essentially of plagioclase and hornblende. Analysis by Hillebrand, No. 669. P. R. C. 82.

Rocks A, C, D, and E described by Diller in Bull. 150, p. 217.

	A.	B.	C.	D.	E.
SiO_2	69.51	58.97	68.20	68.32	55.14
Al_2O_3	15.75	18.60	16.98	15.26	19.10
Fe_2O_3	3.34	5.94	3.75	1.66	6.16
FeO				1.26	.54
MgO	2.09	6.89	2.07	1.32	4.23
CaO	1.71	2.84	4.33	3.26	8.36
Na_2O	3.89	3.05	2.98	4.27	3.71
K_2O	3.34	2.24	1.52	2.81	1.04
H_2O	.56	1.35	.44	1.37	.91
TiO_2				.31	.52
P_2O_5	trace	undet.		.12	.18
MnO				.04	.11
SrO				trace	.07
BaO				.07	trace
Li_2O				trace	trace
	100.19	99.88	100.27	100.07	100.07

F. Dacite, east end of Chaos, northwest base of Lassen Peak. The youngest dacite of the region. Contains quartz, feldspar, biotite, and hornblende, embedded in a clear pumiceous glass. Analysis by W. F. Hillebrand, record No. 670. Described by Diller in Bull. 150, p. 218.

G. Secretion in F. Consists chiefly of plagioclase and hornblende, with some olivine and clear glass. Analysis by Hillebrand, No. 671.

H. Dacite (?), west side of old crater rim near the Thumb, at the head of Mill Creek, Shasta County. Shows phenocrysts of hornblende, plagioclase, and pyroxene, and apparently of quartz, in a gray, microlitic groundmass. Analysis by Hillebrand, No. 674.

I. Streaked dacite, falls of south fork of Bear Creek, Shasta County. Contains plagioclase with a little sanidine, hornblende, quartz, magnetite, some pyroxene inclusions, and glass base. Analysis by R. B. Riggs, record No. 524. P. R. C. 80. Described by Diller in Bull. 150, p. 213.

J. Dacite-tuff, Rice's quarry, 6 miles southeast of Paskenta, Tehama County. Clear glass, with fragments of quartz, feldspar, and hornblende. Analysis by George Steiger, record No. 1427.

	F.	G.	H.	I.	J.
SiO_2	68.72	53.35	63.81	68.10	65.78
Al_2O_3	15.15	19.22	17.07	15.50	14.87
Fe_2O_3	1.16	3.28	2.11	3.20	1.27
FeO	1.76	4.48	2.15	none	1.00
MgO	1.28	4.86	2.28	.10	1.89
CaO	3.30	9.76	4.97	3.02	2.41
Na_2O	4.26	2.89	4.08	4.20	2.58
K_2O	2.78	.99	1.96	3.13	2.71
H_2O at 100°	....	....	....	....	2.87
H_2O above 100°	.74	.77	1.03	2.72	4.32
TiO_2	.31	.56	.38	.15	....
P_2O_5	.09	.10	.10	.03	.08
MnO	.11	.15	.09	trace	trace
SrO	.03	.03	.03	trace	....
BaO	.07	trace ?	.04	.06	....
Li_2O	trace	trace	trace	none	....
	99.76	100.44	100.10	100.21	99.78

K. Pyroxene-andesite, west end of Butte Mountain, Plumas County. Prominent phenocrysts of pyroxene and minute ones of plagioclase, in a dark groundmass containing much globulitic matter. Analysis by W. F. Hillebrand, record No. 411.

L. Pyroxene-andesite, south base of Burney Butte, Shasta County. Numerous small phenocrysts of plagioclase and a few of pyroxene, in a gray groundmass containing much amorphous matter. Analysis by R. B. Riggs, record No. 684.

M. Hornblende-andesite, Tuscan Buttes, 7 miles east of Red Bluff. A few small phenocrysts or fragments of hornblende, in a groundmass consisting mainly of plagioclase and gray microlitic matter. Analysis by Hillebrand, No. 412.

N. Hornblende-andesite, near Buntingville, Lassen County. A few phenocrysts of hornblende in a groundmass consisting mainly of small feldspars. Analysis by T. M. Chatard, record No. 413.

O. Hornblende-andesite, northwest summit, head of Burney Creek, Shasta County. Inconspicuous plagioclase and, rarely, olivine, in a groundmass of plagioclase and pyroxene. Numerous dark spots are due to altered hornblende. Analysis by Riggs, No. 683.

Rocks in this group dried at 105° before analysis.

	K.	L.	M.	N.	O.
SiO_2	55.53	62.44	60.93	67.89	60.04
Al_2O_3	17.63	16.39	18.56	17.29	17.43
Fe_2O_3	2.81	4.66	2.68	2.39	5.39
FeO	3.59	1.00	2.19	.21	.53
MgO	5.85	2.65	2.37	.66	3.51
CaO	8.74	6.22	6.63	3.01	6.65
Na_2O	3.09	3.16	3.79	5.11	4.15
K_2O	.92	2.25	1.33	1.69	1.24
H_2O	1.24	1.02	.90	1.34	.90
TiO_2	.56	.31	.61	.21	.49
P_2O_5	.21	.05	.18	.12	.04
MnO	.08	trace	.10	.12	.08
SrO	.06	trace	.12	.04	?
BaO	.02	.03	.02	.03	.04
Li_2O	none	trace	none	....	trace
SO_3	....	trace	....	....	trace
	100.33	100.18	100.41	100.11	100.49

P. Hypersthene-andesite, 1 mile west of summit on Bidwell's road, Butte County. Rich in small phenocrysts of plagioclase and pyroxene, mostly hypersthene, in a groundmass of the same minerals, with magnetite, and probably some amorphous matter. Analysis by W. F. Hillebrand, record No. 410.

Q. Hypersthene-andesite, old crater at head of Mill Creek. Contains small phenocrysts of plagioclase and hypersthene, in a groundmass of plagioclase, pyroxene, magnetite, etc. Some greenish pseudomorphs suggest former olivine. Analysis by T. M. Chatard, record No. 409.

R. Hypersthene-andesite, 2 miles south of Suppans Mountain, Tehama County. Abundant plagioclase and hypersthene, with traces of hornblende, in a microlitic groundmass. Analysis by Hillebrand, No. 672.

S. Secretion in R. Composed chiefly of plagioclase and hypersthene, with some quartz and amorphous matter. Analysis by Hillebrand, No. 673.

T. Hypersthene-andesite, westb ase of Suppans Mountain, near Lassen Peak, Tehama County. Contains numerous microscopic crystals of plagioclase and hypersthene, in a microlitic groundmass. Analysis by Hillebrand, No. 676.

Rocks dried at 100° to 110° before analysis.

	P.	Q.	R.	S.	T.
SiO_2	55.20	57.11	63.47	57.04	58.08
Al_2O_3	18.68	17.78	16.75	19.11	18.37
Fe_2O_3	3.14	3.54	2.15	4.37	2.92
FeO	4.42	2.74	2.75	2.48	3.38
MgO	4.59	3.41	3.04	3.94	3.35
CaO	8.02	7.21	5.72	7.34	7.05
Na_2O	3.66	3.81	3.94	3.48	3.66
K_2O	1.01	1.86	1.62	1.16	1.33
H_2O	.51	.98	.55	1.09	1.09
TiO_2	.92	.95	.37	.47	.44
P_2O_5	.24	.26	.13	.08	.16
MnO	.14	.33	.09	.12	.13
SrO	.02	trace?	.04	.02	.02
BaO	.03	.03	.04	trace?	.03
Li_2O	none	....	trace	trace	trace
	100.58	100.01	100.66	100.70	100.01

U. Hypersthene-andesite, 1 mile southwest of Thumb, head of Bailey Creek, near Lassen Peak. Abundant but inconspicuous plagioclase and hypersthene, in a microlitic groundmass containing many small crystals of plagioclase. Analysis by W. F. Hillebrand, record No. 675.

V. Hypersthene-andesite, west summit of Crater Peak, Shasta County. Microphenocrysts of feldspar and hypersthene in a groundmass consisting largely of the same minerals, with some amorphous matter. Analysis by Hillebrand, No. 679.

W. Hypersthene-andesite, north slope of Crater Peak. Phenocrysts of plagioclase and hypersthene in a groundmass containing much dark amorphous matter. Analysis by Hillebrand, No. 680.

X. Secretion in W. Composed chiefly of plagioclase, hypersthene, and a globulitic base. Analysis by Hillebrand, No. 681.

Y. Andesitic tuff, Stillwater Creek, 8 miles northeast of Redding. Contains plagioclase, hornblende, rare hypersthene, magnetite, and glass. Fragments of andesite are inclosed. Analysis by W. H. Melville, record No. 1346. Described by Diller in Bull. 150, p. 211.

Rocks dried at 100° to 110° before analysis.

	U.	V.	W.	X.	Y.
SiO_2	59.84	68.12	61.17	53.85	69.51
Al_2O_3	16.81	16.24	17.74	18.53	15.61
Fe_2O_3	1.88	1.26	1.78	1.96	.56
FeO	3.60	2.08	3.51	5.30	1.27
MgO	3.85	1.35	2.76	5.88	.61
CaO	6.30	3.80	5.90	9.66	2.80
Na_2O	3.63	3.89	3.79	2.98	3.43
K_2O	2.13	2.54	1.71	.74	2.81
H_2O	1.04	.40	.83	.45	3.63
TiO_2	.57	.25	.45	.50	trace
P_2O_5	.19	.14	.14	.05	....
Cr_2O_3	trace?	none	none	trace	....
MnO	.14	.10	.12	.12	....
SrO	.02	.02	.04	.04	....
BaO	.07	.09	.06	.03	....
Li_2O	trace	trace	trace	trace	....
	100.07	100.28	100.00	100.09	100.23

3D. BASALTS.

The quartz-basalts are described by Diller in Bull. 79. That from Mitylene was analyzed for comparison with the Cinder Cone series.

A. Quartz-basalt, Cinder Cone, 10 miles northeast of Lassen Peak. Contains plagioclase, pyroxene (mostly hypersthene), olivine, quartz, and much unindividualized base; the latter about 25 per cent. Magnetite is also present; augite occurs sparingly. Analysis by W. F. Hillebrand, record No. 407. P. R. C. 96. Also described in Bull. 150, p. 252.

B. Volcanic bomb from quartz-basalt, Cinder Cone. Analysis by Hillebrand, No. 665.

C. Lapilli from quartz-basalt, Cinder Cone. Analysis by Hillebrand, No. 667. P. R. C. 96. Also described in Bull. 150, p. 249.

D. Volcanic sand, one-half mile northeast of Cinder Cone. Analysis by Hillebrand, No. 663.

E. White pumiceous inclosure from quartz-basalt, Cinder Cone. Analysis by Hillebrand, No. 664. Mainly glass.

Rocks dried at 100° to 110° before analysis.

	A.	B.	C.	D.	E.
SiO_2	57.25	56.70	56.53	55.93	79.49
Al_2O_3	16.45	15.75	17.50	17.34	11.60
Fe_2O_3	1.67	1.29	1.35	1.50	.33
FeO	4.72	5.32	5.03	5.20	.49
MgO	6.74	7.16	5.94	7.29	.09
CaO	7.65	7.67	8.07	8.04	1.64
Na_2O	3.00	3.36	3.51	3.32	4.04
K_2O	1.57	1.56	1.55	1.35	1.52
H_2O	.40	.30	.27	.26	.68
TiO_2	.60	.65	.54	undet.	undet.
P_2O_5	.20	.20	.15	undet.	undet.
Cr_2O_3	....	trace	trace	....	....
MnO	.10	.19	.12	undet.	none
SrO	trace	trace	trace?	(?)	(?)
BaO	.03	.03	trace	(?)	(?)
Li_2O	none	trace	trace	(?)	(?)
	100.38	100.18	100.56	100.23	99.88

F. Quartz-basalt, one-half mile south of Cinder Cone, on border of lava field. Analysis by Hillebrand, No. 666.

G. Quartz-basalt, west end of Lake Bidwell, on border of Cinder Cone lava field. Contains a few grains of quartz, much olivine and plagioclase, less pyroxene, and a globulitic base. Analysis by Hillebrand, No. 661.

H. Quartz-basalt, Silver Lake, near Lassen Peak. Contains occasional grains of quartz, much feldspar and olivine, less pyroxene, and a brownish base. Analysis by Hillebrand, No. 662.

I. Quartz-basalt, resting on dacite, near west base of Lassen Peak. Analysis by Hillebrand, No. 677.

J. Quartz-basalt, island of Mitylene, coast of Asia Minor. Analysis for comparison with the Cinder Cone series, by T. M. Chatard, record No. 845.

Rocks F to I dried at 100° to 110° before analysis.

	F.	G.	H.	I.	J.
SiO_2	54.56	56.18	57.59	56.51	56.58
Al_2O_3	16.04	16.59	16.49	18.10	14.88
Fe_2O_3	.95	1.51	1.22	4.26	2.31
FeO	6.07	5.51	4.89	2.68	3.04
MgO	8.71	7.26	7.72	4.52	3.76
CaO	8.89	7.64	7.40	8.15	8.69
Na_2O	3.05	3.58	3.62	3.23	3.36
K_2O	1.18	1.47	.99	1.15	2.18
H_2O at 105°					.69
H_2O above 105°	.28	.42	.86	.69	1.43
TiO_2	.53	undet.	undet.	.48	.77
P_2O_5	.18	undet.	undet.	.14	.15
Cr_2O_3	trace			trace	trace?
MnO	.17	undet.	undet.	.11	.16
SrO	trace	(?)	(?)	.04	
BaO	.03	(?)	(?)	.04	.07
Li_2O	trace	(?)	(?)	trace	
CO_2					2.32
	100.64	100.16	100.78	100.10	100.39

K. Recent basalt, Pit River. Rich in feldspar and augite, poor in olivine. Partial analysis by F. W. Clarke, record No. 109.

L. Basalt, 1 mile southeast of Paynes Creek, on the road from Red Bluff to Lassen Peak. A normal basalt, rather rich in olivine. Analysis by T. M. Chatard, record No. 405.

M. Basalt, summit of Inskip Crater, 25 miles east of Red Bluff. Mainly feldspar and augite, with a few phenocrysts of olivine. Analysis by Hillebrand and Chatard, record No. 406.

N. Basalt from the cone at south base of Burney Butte, Shasta County. Composed of plagioclase and augite, with some olivine and a globulitic base. Analysis by R. B. Riggs, record No. 685.

O. Basalt, near eastern end of rim of Crater Peak, Shasta County. Contains plagioclase and pyroxene, some of the latter being hypersthene with a trace of olivine. Analysis by R. B. Riggs, record No. 682.

P. Hornblende-basalt, Kosk Creek, near its mouth, by the great bend of Pit River, Shasta County. Contains abundant phenocrysts of hornblende, with a few of plagioclase, pyroxene, and olivine, in a groundmass of plagioclase, augite, and magnetite. The hornblendes are deeply corroded, and some have disappeared, leaving groups of magnetite grains to mark their former presence. Analysis by L. G. Eakins, record No. 1022. Described by Diller in Amer. Geologist, vol. 19, p. 253.

Rocks dried at 105° to 110° before analysis, except in the case of the rock marked L.

	K.	L.	M.	N.	O.	P.
SiO_2	51.92	47.93	50.89	52.63	52.95	44.77
Al_2O_3	19.76	18.51	16.76	17.62	18.25	17.82
Fe_2O_3	11.21	2.07	3.86	6.49	4.36	5.05
FeO		7.25	4.69	3.10	4.19	6.95
MgO	3.38	9.03	8.49	5.64	4.93	8.22
CaO	9.30	11.14	11.72	8.62	8.73	10.36
Na_2O	2.16	2.28	2.61	3.38	3.57	2.13
K_2O	.60	.24	.32	1.73	.77	.92
H_2O	1.54	.76	.41	.79	1.47	2.64
TiO_2		.73	.79	.07	.66	.53
P_2O_5		.11	.09	.47	trace	.72
MnO		.20	.13	trace	.12	trace
SrO				trace	trace	
BaO			trace	.04	.01	
Li_2O				trace	(?)	
CO_2		none				
SO_3				trace	trace	
	99.87	100.25	100.76	100.58	100.01	100.11

3. PLUMAS COUNTY.

Other rocks from this county are described under the heading of the Lassen Peak area. The following rocks, with two exceptions, were collected by H. W. Turner, who supplies the descriptions:

A. Granite, dike in serpentine, south slope of Grizzly Hill. Described by Turner in Amer. Geologist, vol. 17, p. 375. Contains quartz, albite, and muscovite. Analysis by H. N. Stokes, record No. 1562. P. R. C. 757.

B. Meta-rhyolite, near Tower Rock, Grizzly Mountains. Described by Turner in 14th Ann., p. 441. Contains porphyritic quartz, feldspar, and pyrite, in a fine groundmass. Analysis by W. F. Hillebrand, record No. 1273. P. R. C. 741.

C. Meta-rhyolite, near Greenville. Collected by Diller, who finds phenocrysts of quartz in a groundmass chiefly of quartz and feldspar. Analysis by Hillebrand, record No. 1458.

D. Granodiorite, southwest base of Mount Ingalls. Description supplied by Turner. Contains plagioclase, quartz, orthoclase, brown mica, green hornblende, iron oxide, and a little apatite, sphene, and epidote. Analysis by Hillebrand, record No. 1456. P. R. C. 727.

E. Granodiorite, Spanish Peak. Description supplied by Turner. Contains plagioclase, quartz, orthoclase, biotite, hornblende, iron ore, and apatite; also abundant secondary epidote and chlorite. Analysis by Stokes, record No. 1562. P. R. C. 756.

	A.	B.	C.	D.	E.
SiO_2	76.00	73.25	72.77	67.33	59.68
Al_2O_3	14.88	13.25	13.00	15.93	17.09
Fe_2O_3	.65	....	1.28	1.90	2.85
FeO	.10	1.74	2.65	1.59	2.75
MgO	.06	.28	.67	1.63	3.54
CaO	.19	2.23	2.47	4.09	6.62
Na_2O	3.52	2.69	4.95	3.76	3.87
K_2O	2.77	3.79	.34	2.46	1.31
H_2O at 100°	.20	.07	.07	.19	.15
H_2O above 100°	1.42	1.03	1.16	.66	1.00
TiO_2	.04	trace	.22	.36	.65
P_2O_5	.11	trace	.04	.11	.25
MnO	trace	trace	.08	.09	trace
SrO	....	trace?	trace	trace	trace
BaO	trace	trace	trace	.08	.04
Li_2O	....	trace	trace	trace	trace
CO_2	....	1.05	.47	....	.20
SO_3	trace	....	....	....	trace
Cl	trace	....	....	....	.03
F	trace	....	....	....	....
FeS_2	....	.58	....	....	....
	99.94	99.96	100.17	100.18	100.03

F. Rhyolite, 3¼ miles southwest of Grizzly Peak. Description furnished by Turner. Contains sanidine, with less quartz and biotite, in a glassy groundmass. Analysis by Hillebrand, record No. 1461. P. R. C. 776.

G. Hornblende-andesite, 4 miles from Pilot Peak. Described by Turner in 14th Ann., p. 441. Contains plagioclase and hornblende in a groundmass carrying grains of magnetite. Analysis by Hillebrand, record No. 1432. P. R. C. 716.

H. Hornblende-pyroxene-andesite, southwest base of Mount Ingalls. Description supplied by Turner. Contains plagioclase, rhombic pyroxene, augite, brown hornblende, and magnetite, with much glass in the groundmass. Analysis by Hillebrand, record No. 1456. P. R. C. 728.

I. Hypersthene-andesite, Franklin Hill. Description supplied by Turner. Contains plagioclase, rhombic pyroxene, augite, and magnetite. Probably no glass. Analysis by Hillebrand, record No. 1548. P. R. C. 754.

	F.	G.	H.	I.
SiO_2	71.39	60.20	58.47	56.88
Al_2O_3	14.13	17.21	18.80	18.25
Fe_2O_3	.63	3.12	3.34	2.35
FeO	.37	2.69	2.64	4.45
MgO	.08	3.18	2.69	4.07
CaO	1.01	6.04	6.60	7.53
Na_2O	2.89	3.35	3.58	3.29
K_2O	5.69	1.44	2.01	1.42
H_2O at 100°	.42	1.12	.14	.24
H_2O above 100°	3.32	1.18	.92	.50
TiO_2	.17	.57	.51	.45
P_2O_5	.03	.17	.22	.30
MnO	trace	.12	.13	.18
SrO	trace	trace	.05	.04
BaO	.09	.11	.09	.11
Li_2O	trace	trace	trace	trace
	100.22	100.50	100.19	100.06

J. Dolerite, Mount Ingalls. Described by Turner in 14th Ann., p. 441. Contains plagioclase, augite, hypersthene, magnetite, and a few olivines. Analysis by W. F. Hillebrand, record No. 1273. P. R. C. 739.

K. Dolerite, Mount Ingalls. Also in 14th Ann., p. 441. Like J, but with scarcely any olivine. Analysis by Hillebrand, record No. 1432. P. R. C. 740.

L. Basalt, 4 miles southeast of Mount Ingalls. Also in 14th Ann., p. 441. Contains plagioclase, olivine, augite, and magnetite. Analysis by Hillebrand, record No. 1273.

M. Olivine-basalt, 1¼ miles from Franklin Hill. Contains plagioclase, augite, partly altered olivine, magnetite, and probably some glass. Description supplied by Turner. Analysis by George Steiger, record No. 1596. P. R. C. 755.

N. Serpentine, Greenville. Described by Diller in Bull. 150, p. 372. Besides serpentine, the rock contains some magnetite and less chromite, with remnants of the pyroxene from which the serpentine was in great part derived. Analysis by W. H. Melville, record No. 1346. P. R. C. 145.

	J.	K.	L.	M.	N.
SiO_2	53.91	52.81	50.56	51.21	39.14
Al_2O_3	17.95	16.60	14.71	17.59	2.08
Fe_2O_3	2.21	2.66	3.54	4.71	4.27
FeO	4.80	6.13	8.90	4.42	2.04
MgO	5.52	6.12	4.07	7.12	39.84
CaO	10.40	10.14	7.58	10.36	trace
Na_2O	2.90	2.79	2.94	2.49	
K_2O	1.34	1.05	2.10	.91	
H_2O at 100°	.20	.38	1.06	.58	12.70
H_2O above 100°	.20	.54	1.12	1.07	
TiO_2	.52	.84	1.71	.31	
P_2O_5	.21	.23	1.14	.09	
MnO	.10	undet.	.13	trace	
SrO	trace	trace	trace ?		
BaO	.05	.03	.25	none	
Li_2O	trace	trace	trace ?	none	
Chromite					.11
	100.31	100.32	99.81	100.86	100.18

4. BUTTE COUNTY.

Rocks from this county are also to be found under the heading of the Lassen Peak region. The following rocks were collected by H. W. Turner, to whom the petrographic data are due. Analyses, with two exceptions, by W. F. Hillebrand, record Nos. 1432, 1456, 1461, and 1548. Analysis G is by H. N. Stokes, record No. 1562.

A. Granodiorite, north side of south fork of Feather River, opposite Enterprise. Described in 14th Ann., p. 441. Contains plagioclase, potash feldspar, quartz, hornblende, brown mica, and accessory minerals. The ferromagnesian minerals are largely altered to chlorite. P. R. C. 720.

B. Granodiorite, 2 miles east of Bangor. Composition like A. The mica is largely altered to chlorite. See 14th Ann., p. 441. P. R. C. 717.

C. Diorite, South Honcut Creek. Description supplied by Turner. Contains feldspar, probably all plagioclase, brown hornblende, and a little chlorite. P. R. C. 775.

D. Quartz-diorite, 4.6 miles south of Table Mountain, on ridge between Butte and Plumas counties. Described in 17th Ann., Part I, p. 521. Contains hornblende, feldspar, quartz, rutile, and a little secondary chlorite and epidote. P. R. C. 758.

E. Amphibole separated from E. Analysis by William Valentine, record No. 1723. Cr_2O_3 determination by Hillebrand.

	A.	B.	C.	D.	E.
SiO_2	70.36	63.43	57.87	54.64	50.08
Al_2O_3	15.47	14.20	16.30	12.06	7.97
Fe_2O_3	.98	1.54	1.71	1.81	2.69
FeO	1.17	4.56	3.86	5.03	6.71
MgO	.87	2.35	5.50	11.86	16.31
CaO	3.18	5.51	5.53	7.74	11.21
Na_2O	4.91	3.49	5.01	2.35	1.22
K_2O	1.71	2.19	.75	1.01	.46
H_2O at 100°	.06	.15	.26	.12	....
H_2O above 100°	1.00	1.50	2.40	2.44	1.40
TiO_2	.20	.73	.53	.61	.76
P_2O_5	.11	.11	.27	.08	trace
V_2O_3	....	....	....	.03	....
Cr_2O_3	....	....	....	....	.16
NiO	....	....	....	.05	....
MnO	trace	.03	.08	.13	.49
SrO	trace	trace	trace	trace	....
BaO	.06	.06	.05	.05	none
Li_2O	trace	none	trace	trace	....
	100.08	99.85	100.12	100.01	100.46

F. Meta-andesite-tuff. Described in 14th Ann., p. 441. Contains plagioclase, augite, epidote, chlorite, and secondary hornblende. P. R. C. 719.

G. Uralite-diorite, 1 mile southeast of Forbestown. Described in 17th Ann., Part I, p. 521. Contains plagioclase, hornblende, and magnetite. P. R. C. 751.

H. Basalt, Oroville, Table Mountain. Described in 14th Ann., p. 441. Contains plagioclase, olivine, augite, and magnetite. P. R. C. 718.

I. Altered peridotite, 5 miles northeast of Strawberry Valley. Largely serpentine, with olivine, hornblende, magnetite, and calcite or dolomite. P. R. C. 742.

	F.	G.	H.	I.
SiO_2	54.66	51.07	50.66	44.81
Al_2O_3	15.85	14.93	13.97	a 1.88
Fe_2O_3	1.82	6.44	2.55	1.98
FeO	5.12	5.98	10.20	4.52
MgO	5.64	4.84	4.45	30.91
CaO	8.75	7.89	8.08	6.58
Na_2O	3.46	5.04	3.32	.15
K_2O	.47	.16	1.95	
H_2O at 100°	.25	.24	.27	.15
H_2O above 100°	2.48	1.73	.43	6.88
TiO_2	.67	1.65	2.39	....
P_2O_5	.15	.19	1.01	.02
Cr_2O_3	....	....	....	.29
MnO	.18	.22	.29	.13
NiO	trace?	....	trace	.09
SrO	trace	....	trace	none
BaO	.04	....	.22	none
Li_2O	none	....	none	....
CO_2	.39	....	....	1.79
Cl	....	trace	.02	....
F	....	trace	....	....
SO_3	....	trace	....	....
FeS_2	.09	....	....	....
	100.02	100.38	99.81	100.18

a Includes possible TiO_2.

5. SIERRA COUNTY.

Rocks collected and described by H. W. Turner. See paper in 17th Ann., Part I, p. 521. Additional details, supplied by Turner, are given here. Analyses A to H by W. F. Hillebrand, record Nos. 1456 and 1548. Analysis I by H. N. Stokes, record No. 1514.

A. Granulite (aplite), Yuba Gap, road east of Sierra Buttes. Contains orthoclase, microcline, quartz, plagioclase, some shreds of greenish mica, and a little iron ore, chlorite, and apatite. P. R. C. 730.

B. Granulite (aplite), dike east of Milton. Contains orthoclase, quartz, plagioclase, a little microcline, brown mica, and iron ore. P. R. C. 734.

C. Biotite-quartz-monzonite, Indian Valley. Contains plagioclase, orthoclase, quartz, brown mica, apatite, and iron ore. P. R. C. 737.

D. Quartz-diorite-porphyry, dike in Indian Valley granite. Contains plagioclase, hornblende, biotite, and quartz. P. R. C. 738.

E. Quartz-mica-diorite, large area east of Milton. Contains plagioclase, a turbid feldspar which is apparently not orthoclase, quartz, green hornblende, brown mica, iron ore, and apatite. P. R. C. 732.

	A.	B.	C.	D.	E.
SiO_2	76.03	75.97	68.65	66.65	57.26
Al_2O_3	13.39	13.07	16.34	17.61	16.51
Fe_2O_3	.48	.61	.93	.93	3.27
FeO	.31	.39	1.48	1.67	5.19
MgO	.05	.14	1.29	1.26	3.41
CaO	1.28	1.49	3.07	4.44	6.69
Na_2O	2.98	2.51	4.85	4.59	2.65
K_2O	5.18	5.62	1.85	1.70	2.93
H_2O at 100°	.15	.14	.24	.03	.20
H_2O above 110°	.34	.24	.62	.41	.95
TiO_2	.07	.09	.28	.33	.53
P_2O_5	.03	trace	.15	.18	.30
MnO	trace	trace	.08	.07	.18
SrO	trace	.03	.07	....	.06
BaO	.04	.14	.09	.12	.10
Li_2O	none	trace	trace	trace	trace
	100.33	100.44	99.99	99.99	100.23

F. Diabase-porphyry, dike east of Milton. Contains labradorite d other plagioclase, augite, and hornblende, the last mineral being rhaps secondary. P. R. C. 733.

G. Hypersthene-andesite, point northeast of Goodyears Bar. Contins plagioclase and rhombic pyroxene, a little augite, and scales hich seem to represent former biotite, now replaced by magnetite. . R. C. 731.

H. Hornblende-pyroxene-andesite, dike southeast of Poker Flat. ontains plagioclase, augite, hornblende, magnetite, some glass, and casional quartz. P. R. C. 736.

I. Quartz-bearing andesite, northwest of Downieville. Cont[illegible] agioclase, augite, enstatite, magnetite, occasional quartz, and probly glass. P. R. C. 753.

	F.	G.	H.	I.
SiO_2	51.27	66.94	50.34	60.02
Al_2O_3	12.14	16.49	17.61	16.07
Fe_2O_3	2.51	1.41	3.63	2.17
FeO	6.71	1.87	2.28	3.46
MgO	10.88	1.98	3.50	4.57
CaO	10.32	4.77	6.45	7.01
Na_2O	2.00	3.88	3.40	3.55
K_2O	1.63	1.65	1.94	1.59
H_2O at 100°	.17	.35	.64	.24
H_2O above 100°	1.16	.22	.74	.45
TiO_2	.60	.30	.32	.42
P_2O_5	.21	.12	.25	.17
Cr_2O_3	....	....	....	trace
NiO	.04	....	....	....
MnO	.21	.13	.12	.10
SrO	trace?	.05	.04	trace
BaO	.07	.07	.11	.08
Li_2O	trace	trace	trace	none
SO_3	....	....	....	.06
	99.92	100.23	100.37	99.96

6. NEVADA CITY AND GRASS VALLEY.

Rocks of a mining district in Nevada County, described by Lindgren in 17th Ann., Part II, p. 1.

A. Granodiorite, 1 mile southeast of Nevada City. Contains hornblende, biotite, quartz, plagioclase, orthoclase, magnetite, apatite, sphene, and pyrite. Analysis by W. F. Hillebrand, record No. 1478.

B. Granodiorite, Kate Hayes Hill, Grass Valley. Contains plagioclase, orthoclase, quartz, hornblende, pyrite, magnetite, apatite, sphene, and zircon. Analysis by Hillebrand, No. 1478.

C. Hornblende-porphyrite, Nevada City. Contains feldspar, hornblende, quartz, epidote, sericite, and biotite. Analysis by H. N. Stokes, record No. 1531.

D. Quartz-porphyrite, New Ophir claim, Grass Valley. Contains plagioclase, quartz, uralite, epidote, and augite, and hornblende altered into chlorite. Analysis by Stokes, No. 1531.

E. Diabase, near Maryland mine, Grass Valley. Contains feldspar, augite, hornblende, ilmenite, pyrrhotite, pyrite, and some chlorite. Analysis by Stokes, No. 1522.

F. Diabase, Grass Valley. Contains feldspar, pyroxene, hornblende, ilmenite, pyrrhotite, pyrite, and chlorite, and probably a little quartz. Analysis by Stokes, No. 1522.

	A.	B.	C.	D.	E.	F.
SiO_2	66.65	63.85	62.09	63.39	51.01	53.19
Al_2O_3	16.15	15.84	16.69	16.58	11.89	17.12
Fe_2O_3	1.52	1.91	1.45	1.41	1.57	4.35
FeO	2.36	2.75	3.76	3.08	6.08	5.16
MgO	1.74	2.07	1.93	2.15	8.87	3.98
CaO	4.53	4.76	6.08	4.76	10.36	9.39
Na_2O	3.40	3.29	3.36	3.47	4.17	2.79
K_2O	2.65	3.08	1.84	2.79	.15	.28
H_2O at 110°	.18	.28	.19	.22	.24	.17
H_2O above 110°	.72	1.65	1.47	1.87	2.09	1.21
TiO_2	.38	.58	.32	.44	.98	1.34
P_2O_5	.10	.13	.39	.14	.17	.13
Cr_2O_3					.04	none
MnO	.10	.07	trace	trace	trace	trace
SrO	trace	trace				
BaO	.07	.06	.10	.11	none	trace
Li_2O	trace	trace				
SO_3			.10			
FeS_2	.02	.04			1.73	.94
CuS (?)					trace	
	100.57	100.36	99.77	100.41	99.35	100.05

G. Wall rock, Federal Loan mine. A siliceous argillite, of sedimentary origin. Contains quartz, feldspar, biotite, pyrrhotite, and a little calcite. Analysis by Hillebrand, No. 1478.

H. Altered wall rock, Providence mine. Derived from granodiorite. Analysis by Hillebrand, No. 1478.

I. Altered wall rock, Providence mine, back vein. Derived from granodiorite and schist. Analysis by Hillebrand, No. 1478.

J. Altered wall rock, North Star mine. Derived from uralite-diabase. Contains quartz, sericite, calcite, pyrite, and sphene. Analysis by Hillebrand, No. 1478.

K. Altered country rock, Idaho mine. Derived from serpentine. Analysis by Hillebrand, No. 1478.

	G.	H.	I.	J.	K.
SiO_2	73.63	60.26	59.76	45.74	36.19
Al_2O_3	10.54	15.73	14.45	5.29	4.93
Fe_2O_3	1.87	1.25	1.04	.13	.21
FeO		2.68	3.52	2.06	5.36
MgO	1.84	1.82	2.26	.94	22.94
CaO	2.47	5.44	6.09	23.85	4.60
Na_2O	1.81	1.92	1.12	.11	.16
K_2O	1.89	3.71	3.73	1.29	.06
H_2O at 110°	.11	.33	.26	.22	.18
H_2O above 110°	1.07	2.54	2.58	1.07	2.87
TiO_2	.52	.42	.46	.36	.16
P_2O_5	.13	.12	.16	.07	.05
MnO	trace?	.04	.09	.26	.12
NiO					.10
SrO	trace	trace	trace?	none	trace
BaO	.12	.07	.05	trace	trace
Li_2O	trace	trace	trace	trace	trace
CO_2	.62	3.99	4.47	18.91	21.82
FeS_2		.08	.24	.49	.22
Fe_7S_8	3.16				
Organic C	.59				
	100.37	100.40	100.28	100.79	99.97

L. Bleached country rock, next to vein, Osborne Hill mine. Derived from sandstone. Analysis by George Steiger, record No. 1541.

M. Altered wall rock, Empire mine. Derived from granodiorite. Analysis by Steiger, No. 1541. Sp. gr., 2.782, 20°.

N. Altered wall rock, Ebaugh tunnel. Derived from granodiorite. Mainly quartz and sericite, with pyrite, apatite, sphene, and carbonates. Analysis by Steiger, No. 1541. Sp. gr., 2.747, 20°.

O. Altered wall rock, Federal Loan mine. Derived from siliceous argillite. Analysis by Steiger, No. 1541.

	L.	M.	N.	O.
SiO_2	71.97	58.43	56.25	34.91
Al_2O_3	15.75	17.40	17.65	15.55
Fe_2O_3	.77	.77	.76	.17
FeO	.45	2.19	2.64	4.96
MgO	.80	1.50	1.69	4.58
CaO	.80	5.25	4.46	11.10
Na_2O	.33	1.76	.30	.19
K_2O	4.88	4.03	6.01	4.28
H_2O at 100°	.30	.30	.30	.30
H_2O above 100°	2.16	2.61	2.36	1.86
TiO_2	.88	none	.25	1.65
P_2O_5	.15	.13	.21	.82
MnO	none	none	none	none
BaO	trace	none	.03	none
SO_3	trace	none	none	none
CO_2	.38	4.04	4.82	15.57
FeS_2	.56	1.59	2.87	4.20
	100.18	100.00	100.60	100.14

7. PLACER COUNTY.

First, a series of rocks from the Ophir mining district, described by indgren in 14th Ann., p. 249. Analyses by W. F. Hillebrand, record os. 1419, 1433, 1434.

A. Granodiorite, quarries at Lincoln, 8 miles west of Ophir. Con-ins feldspars, quartz, biotite, and hornblende.

B. Pyritiferous amphibolite, Conrad tunnel. Partly altered. Con-ins pyrite, hornblende, magnetite, feldspars, quartz, epidote, chlorite, few scales of mica, rutile, and carbonates. Sp. gr. 2.901, 23°.

C. Dike rock, near camptonite, Casey's tunnel, Flat Ledge, Dun-n Hill. Contains hornblende, feldspars, pyrite, and apatite, with condary epidote and quartz.

D. Altered wall rock, Mina Rica vein. Sp. gr. 2.979, 20°.

E. Altered wall rock, Plantz vein. These rocks, D and E, contain uartz, muscovite, a little chlorite, pyrite, and sphene, with carbonates f calcium, magnesium, and iron.

	A.	B	C.	D.	E.
SiO_2	65.54	45.56	60.09	37.01	46.13
Al_2O_3	16.52	14.15	16.43	12.99	15.82
Fe_2O_3	1.40	1.20	2.28	.43	.89
FeO	2.49	9.83	3.01	3.57	2.27
MgO	2.52	6.76	4.37	5.49	2.13
CaO	4.88	2.30	5.76	9.78	10.68
Na_2O	4.09	1.57	4.52	.13	.17
K_2O	1.95	1.18	.70	4.02	5.30
H_2O at 100°	.12	.23	.20	.13	.12
H_2O above 100°	.59	4.84	1.16	1.92	2.42
TiO_2	.39	1.11	.63	.85	.67
P_2O_5	.18	.14	.12	.06	.10
MnO	.06	.25	.12	.24	.09
Ni, Zn		traces		traces	traces
SrO	trace	trace	trace	trace	trace
BaO	trace	trace	trace	trace	trace
Li_2O	trace	trace	none	trace	trace
SO_3		.03	trace	.04	.04
CO_2		3.04	.07	15.04	11.24
FeS_2		7.86	.34	7.99	1.61
Cu_2S (?)		.10			
	100.73	100.15	99.80	99.69	99.68

Second, rocks from other localities in Placer County. Studied also by Lindgren, who furnishes the petrographic data. Analysis A by W. H. Melville, record No. 1346; B, C, D, and E by W. F. Hillebrand, record No. 1419.

A. Granite, Rocklin. A normal granite, containing quartz, orthoclase, plagioclase, biotite, muscovite, magnetite, apatite, and zircon, with some secondary chlorite and epidote derived from the biotite. Described by Lindgren in Bull. 150, p. 170. P. R. C. 66.

B. Granodiorite, Donner Pass. Contains plagioclase, orthoclase, quartz, hornblende, biotite, and sphene.

C. Gabbro, 2 miles south of Emigrant Gap, on road to Onion Valley. Contains biotite, hypersthene, diallage, plagioclase, and orthoclase.

D. Gabbro, same locality as C. Contains hypersthene, diallage, plagioclase, and orthoclase.

E. Augite-granite, southeast spur of English Mountain. Contains "basic" plagioclase, augite, and quartz.

	A.	B.	C.	D.	E.
SiO_2	73.00	59.48	55.40	55.87	64.67
Al_2O_3	16.38	17.25	15.32	13.52	16.62
Fe_2O_3	none	2.15	2.70	2.70	.51
FeO	.99	4.06	5.49	5.89	.76
MgO	.48	2.67	5.75	6.51	2.26
CaO	2.42	6.50	9.90	8.87	9.50
Na_2O	4.53	3.53	2.89	2.42	4.10
K_2O	1.87	2.27	1.52	1.72	.34
H_2O at 100°	.52	.09	.03	.09	.08
H_2O above 100°		.71	.38	1.56	.37
TiO_2	....	.93	.60	.56	.51
P_2O_5	....	.33	.22	.25	.12
MnO	....	.11	.11	.10	trace
SrO	....	trace	none	none	trace
BaO	....	.09	.07	.02	.02
Li_2O	....	trace	trace	trace	trace
	100.19	100.17	100.38	100.08	99.86

8. ELDORADO COUNTY.

A. Granitite, Placerville canal, one-third mile north of Ditch Camp). 7. Collected by W. Lindgren, who reports it as containing biotite, thoclase, plagioclase, and quartz. Analysis by George Steiger, cord No. 1591.

B. Granodiorite, 2 miles south of Silver Lake Hotel. Collected by indgren, who reports it as containing hornblende, biotite, plagioclase, d quartz. Analysis by Steiger, No. 1591. Analyses A and B are blished by Lindgren in Amer. Journ. Sci., 4th ser., vol. 3, p. 306.

C. Porphyrite, 1 mile southwest of Latrobe. Published by Turner 17th Ann., Part I, p. 521. Contains abundant plagioclase, less gite, calcite or dolomite, iron disulphide, a little chlorite, and secdary greenish mica. Analysis by W. F. Hillebrand, record No. 32. P. R. C. 721.

	A.	B.	C.
SiO_2	77.68	67.45	68.58
Al_2O_3	11.81	15.51	13.04
Fe_2O_3	.72	1.76	.26
FeO	.51	2.21	3.40
MgO	.18	1.10	1.01
CaO	.72	3.60	3.22
Na_2O	2.96	3.47	4.94
K_2O	5.00	3.66	1.90
H_2O at 100°	.04	.14	.16
H_2O above 100°	.27	.63	1.00
TiO_2	.14	.58	.57
P_2O_5	.10	.12	.20
MnO	trace	....	.15
SrO	....	....	trace
BaO	....	....	.10
CO_2	....	....	1.31
FeS_2	....	....	.15
	100.13	100.23	99.99

9. AMADOR COUNTY.

Rocks collected by H. W. Turner, and analyses published in 14th Ann., p. 441, and 17th Ann., Part I, p. 521. Additional data supplied by Turner. Analyses by W. F. Hillebrand, record Nos. 1432, 1456, and 1597.

A. Rhyolite, south point of Buena Vista Peak. Contains sanidine, quartz, and biotite in a glassy groundmass. P. R. C. 729.

B. Quartz-monzonite, north fork of Mokelumne River. Contains plagioclase, microcline, quartz, abundant biotite, iron ore, sphene, apatite, and perhaps rutile. P. R. C. 770.

C. Quartz-monzonite, north fork of the Mokelumne River. Like B. P. R. C. 765.

D. Quartz-porphyrite-schist, 2½ miles southeast of Buena Vista Peak. Contains porphyritic quartz and hornblende, also calcite and other carbonates. See 14th Ann. P. R. C. 723.

E. Quartz-diorite-gneiss, north fork of Mokelumne River. Contains plagioclase, hornblende, quartz, brown mica, accessory biotite, and iron oxide. P. R. C. 764.

F. Diorite-porphyry, north fork of Mokelumne River. Contains plagioclase, brown hornblende, epidote, and a little sulphide of iron and chlorite. P. R. C. 769.

	A.	B.	C.	D.	E.	F.
SiO_2	73.23	70.75	70.43	70.29	57.41	55.18
Al_2O_3	12.73	15.13	15.51	11.83	17.71	17.35
Fe_2O_3	.99	.98	.96	1.30	2.16	2.77
FeO	.16	1.43	1.28	2.08	5.01	3.90
MgO	.22	.73	.37	1.24	3.38	4.80
CaO	.61	3.09	2.76	2.30	6.73	7.98
Na_2O	1.91	3.05	2.75	2.68	3.12	3.42
K_2O	5.17	3.62	5.14	3.05	1.82	1.42
H_2O at 100°	.53	.10	.08	.10	.20	.16
H_2O above 100°	4.51	.51	.40	1.35	1.14	1.52
TiO_2	.09	.42	.24	.29	1.04	.83
P_2O_5	.02	.10	.11	.07	.24	.20
NiO	....	none	(?)	....	.02	.03
MnO	trace	trace	trace	.12	.15	.15
SrO	none	.04	.05	trace?	.04	.06
BaO	.02	.12	.20	.07	.09	.04
Li_2O	trace	trace	trace	none	trace	trace
CO_2	....	none	none	3.25	none	none
FeS_2	....	.06	trace	....	none	.28
	100.19	100.13	100.28	100.02	100.26	100.09

G. Diorite, north fork of Mokelumne River. Contains quartz, feldar, biotite, sphene, epidote, and secondary chlorite. P. R. C. 771.

H. Diorite, north fork of Mokelumne River. Contains plagioclase. artz, hornblende, biotite, apatite, iron ore, epidote, and chlorite, R. C. 772.

I. Plagioclase-gneiss, north fork of Mokelumne River. Contains agioclase, hornblende, biotite, and apatite. P. R. C. 768.

J. Plagioclase-gneiss, north fork of Mokelumne River. Contains agioclase, hornblende, brown mica, apatite, epidote, and grains of on ore. P. R. C. 767.

	G.	H.	I.	J.
SiO_2	69.66	55.86	52.21	46.63
Al_2O_3	17.57	19.30	18.79	19.47
Fe_2O_3	.21	.91	2.71	3.26
FeO	1.04	4.78	5.30	6.63
MgO	.58	2.94	5.11	5.37
CaO	4.54	7.31	8.01	9.15
Na_2O	4.91	3.52	3.31	3.19
K_2O	.71	1.52	1.60	1.55
H_2O at 110°	.05	.19	.12	.10
H_2O above 110°	.50	1.23	1.35	1.61
TiO_2	.21	1.20	1.16	1.82
P_2O_5	.03	.38	.36	.66
V_2O_3	....	....	....	.02
NiO	none	trace	trace	.02
MnO	trace	.16	.06	.21
SrO	.05	.04	....	.06
BaO	.03	.13	.08	.14
Li_2O	none	trace	trace	trace
CO_2	none	none	none	none
FeS_2	trace?	.39	.06	.19
	100.09	99.86	100.23	100.08

K. Wollastonite-gneiss, north fork of Mokelumne River. Main wollastonite, but garnet, quartz, and sphene are also present. P. C. 766.

L. Melaphyr-tuff, altered basalt, west of Jackson. Contains augi and plagioclase, with secondary quartz, chlorite, and chrysoti Originally glassy in part, but devitrified. See 14th Ann. P. R. C. 7

M. Reddish-brown mica separated from pyroxenic-gneiss, north fo of Mokelumne River, about 1 kilometer above mouth of Bear Riv Described by Turner in Amer. Journ. Sci., 4th series, vol. 7, p. 2 Analysis by William Valentine, record No. 1736.

	K.	L.	M.
SiO_2	50.67	49.24	36.62
Al_2O_3	6.37	14.79	14.37
Fe_2O_3	.31	1.36	4.04
FeO	.50	8.00	17.09
MgO	.58	6.89	9.68
CaO	40.34	10.74	1.48
Na_2O	.14	2.76	.45
K_2O	.22	.88	8.20
H_2O at 110°	.08	.20	.90
H_2O above 110°	.31	2.97	3.26
TiO_2	.20	.96	3.03
P_2O_5	none	.17	none
NiO	none		
MnO	trace	.18	.40
SrO	none	trace	trace
BaO	none	.04	.33
Li_2O	none	trace	trace
F			.10
CO_2	.52	.90	
	100.24	100.08	99.95
Less O			.04
			99.91

10. CALAVERAS COUNTY.

Rocks collected by H. W. Turner, and described in 14th Ann., p. 441. Additional data supplied by Turner relative to analysis B. Analyses by W. F. Hillebrand, record No. 1432.

A. Meta-dacite, 1¾ miles southeast of Milton. Contains quartz, feldspar, and hornblende. P. R. C. 777.

B. Meta-dacite, 1½ miles northeast of Milton. Contains feldspar, quartz, epidote, chlorite, and iron ore, in a groundmass made up probably of feldspar and quartz. P. R. C. 752.

C. Meta-andesite, 1½ miles northward from Jenny Lind. Contains quartz, plagioclase, epidote, and chlorite derived from augite.

	A.	B.	C.
SiO_2	72.24	71.19	61.37
Al_2O_3	13.84	13.81	15.41
Fe_2O_3	1.45	1.45	3.15
FeO	1.86	1.68	3.89
MgO	1.10	.74	3.48
CaO	3.40	2.87	4.42
Na_2O	4.43	4.24	3.76
K_2O	.39	1.82	.34
H_2O at 100°	.17	.15	.29
H_2O above 100°	.69	.92	2.70
TiO_2	.41	.35	.60
P_2O_5	.10	.08	.08
MnO	.12	.07	.47
SrO	trace	trace	trace
BaO	.08	.16	.08
CO_2	....	.82	....
	100.28	100.35	100.04

11. TUOLUMNE COUNTY.

Rocks collected by H. W. Turner, and partly described in his papers in the 14th and 17th Annuals. The latites were named and described by Ransome in Bull. 89. Some additional data have been furnished by Turner.

A. Soda-syenite-porphyry, dike east of Moccasin Creek. Consists mainly of albite, with a greenish mineral which is probably ægirite. Analysis by H. N. Stokes, record No. 1563. P. R. C. 773.

B. Augite-syenite, dike on Turnback Creek, about 1 mile north of Carter post-office. Hitherto unpublished. Contains orthoclase and augite, with less plagioclase and quartz. Analysis by Stokes, No. 1642.

C. Diorite, dike 1½ miles southeasterly from Sonora. Contains feldspar largely altered to hornblende. A few black grains are probably iron ore. Analysis by W. F. Hillebrand, record No. 1548. P. R. C. 759.

D. Quartz-pyroxene-diorite, large area east of Sonora. Contains plagioclase, quartz, biotite, augite, rhombic pyroxene, and a trace of iron ore. Analysis by Hillebrand, No. 1548. P. R. C. 760.

E. Diorite, dike about 1½ miles southeasterly from Sonora. Contains altered plagioclase and hornblende, with epidote, chlorite, and iron disulphide as secondary products. Analysis by Hillebrand, No. 1548. P. R. C. 761.

	A.	B.	C.	D.	E.
SiO_2	67.53	61.28	58.05	57.80	53.46
Al_2O_3	18.57	14.71	15.46	16.43	14.81
Fe_2O_3	1.13	1.21	1.69	1.62	2.60
FeO	.08	2.85	5.09	6.51	5.15
MgO	.24	1.69	4.84	4.14	7.27
CaO	.55	5.61	6.94	7.21	8.44
Na_2O	11.50	2.99	2.86	2.35	2.64
K_2O	.10	7.70	2.14	2.29	1.30
H_2O at 110°	.15	.28	.10	.11	.12
H_2O above 110°	.31	.43	2.02	.38	2.13
TiO_2	.07	.41	.72	.70	.70
P_2O_5	.11	.16	.16	.19	.16
MnO	trace	trace	.14	.18	.18
NiO			none	.03	.05
SrO	trace	.04	trace	trace?	trace
BaO		.72	.07	.09	.05
Li_2O			trace	trace	trace
SO_3	trace	.08			
CO_2			none	none	.44
F	trace				
FeS_2			none	none	.26
	100.34	100.16	100.28	100.03	99.76

F. Biotite-augite-latite, 4 miles southwest of Clover Meadow. Called "trachyte-andesite-tuff" in former edition of this bulletin. Contains plagioclase, biotite, augite, magnetite, apatite, and glass. Analysis by W. F. Hillebrand, record No. 1597. P. R. C. 762.

G. Augite-latite, Dardanelle flow, near Clover Meadow. Called "trachyte-andesite" in former edition. Contains plagioclase, in part labradorite, augite, iron ore, some olivine, apatite, and brown glass. The potassium is probably in the glass, as no potash mineral was observed. Analysis by H. N. Stokes, record No. 1645. P. R. C. 785.

H. Augite-latite, Table Mountain. Called "basalt" in former edition. Contains labradorite, olivine, augite, and magnetite. Analysis by Hillebrand, record No. 1273. P. R. C. 724.

I. Augite-latite, Table Mountain, near Clover Meadow. Contains labradorite, augite, olivine, magnetite, apatite, and glass. Analysis by George Steiger, record No. 1697.

	F.	G.	H.	I.
SiO_2	62.33	59.43	56.19	56.78
Al_2O_3	17.30	16.68	16.76	16.86
Fe_2O_3	3.00	2.54	3.05	3.56
FeO	1.63	3.48	4.18	2.93
MgO	1.05	1.84	3.79	3.41
CaO	3.23	4.09	6.53	6.57
Na_2O	4.21	3.72	2.53	3.19
K_2O	4.46	5.04	4.46	3.48
H_2O at 110°	.44	.27	.34	.15
H_2O above 110°	.75	.72	.66	1.21
TiO_2	1.05	1.38	.69	1.15
P_2O_5	.29	.58	.55	.42
ZrO_2	.04	.08		
V_2O_3	.01			
MnO	.08	trace	.10	none
SrO	.05	trace	trace	
BaO	.24	.14	.19	trace
Li_2O	trace	none	trace	
CO_2				.18
Cl		.05		
F		trace		
C	.11			
FeS_2	.06			
	100.33	100.04	100.02	99.89

J. Amphibole-gabbro, Beaver Creek, Big Trees quadrangle. Contains labradorite and amphibole, with a little pyrite and pyrrhotite. Analysis by H. N. Stokes, record No. 1752.

K. Amphibole separated from J. Analysis by William Valentine, record No. 1733.

L. Olivine-gabbro, just east of south end of Phœnix reservoir. Contains plagioclase, a few grains of alkali feldspar, augite, rhombic pyroxene, amphibole, olivine, magnetite, and iron sulphide, with a little secondary chlorite and epidote. Analysis by H. N. Stokes, record No. 1750.

For description of J and K see Turner, Amer. Jour. Sci., 4th series, vol. 7. p. 294. The description of L is hitherto unpublished.

	J.	K.	L.
SiO_2	47.27	46.08	43.41
Al_2O_3	20.82	10.52	23.15
Fe_2O_3	1.85	2.81	3.72
FeO	4.26	8.30	4.39
MgO	6.44	14.40	7.65
CaO	13.02	12.64	14.27
Na_2O	2.75	1.62	.82
K_2O	.22	.34	.22
H_2O at 110°	.08	.17	.18
H_2O above 110°	1.27	1.97	1.53
TiO_2	.92	.77	.39
P_2O_5	.74	.18	.02
V_2O_3	.02	.04	....
Cr_2O_3	trace	....	none
MnO	trace	.15	.08
SrO	trace	....	....
Li_2O	none	none	trace
CO_2	....	....	.10
FeS_2	.20	....	.14
Cl	trace	....	trace
	99.86	99.99	100.07

12. MARIPOSA COUNTY.

Rocks collected by H. W. Turner, and partly described in his papers in the 14th and 17th Annuals. Additional data supplied by Turner.

A. Soda-granulite or aplite, about 4 miles west of Mariposa. See 17th Ann., Part I, p. 721. Contains plagioclase (albite?) and micropegmatite, with less epidote, quartz, sphene, and apatite. Analyses by W. F. Hillebrand, record No. 1461. P. R. C. 748.

B. Micropegmatite, Agua Fria Creek. See 17th Ann., Part I, p. 691. Contains quartz, plagioclase, brown mica, epidote, and a little iron ore. Analysis by Hillebrand, No. 1461. P. R. C. 746.

C. Soda-granite-porphyry, Merced River, below the mouth of the north fork. Published in 17th Ann. Contains feldspar, largely albite, hornblende, muscovite, abundant epidote, apatite, and a little iron ore. Analysis by George Steiger, record No. 1573. P. R. C. 774.

D. Granite-porphyry, about one-fourth of a mile north of Lake Tenaya, Yosemite National Park. See 14th and 17th Annuals. Contains orthoclase, quartz, plagioclase, and biotite, with a little iron ore and sphene. Analysis by Hillebrand, record No. 1432. P. R. C. 726.

E. Granite, west of Lake Tenaya, Yosemite National Park. See 14th and 17th Annuals. Contains quartz, orthoclase, plagioclase, and biotite, with some hornblende, iron ore, sphene, and apatite. Analysis by Hillebrand, No. 1432. P. R. C. 725.

	A.	B.	C.	D.	E.
SiO_2	74.21	73.18	71.88	72.48	66.28
Al_2O_3	14.47	13.66	15.57	14.06	16.03
Fe_2O_3	.35	.21	1.07	.89	1.80
FeO	.50	2.24	.30	1.05	1.88
MgO	.28	.93	.68	.62	1.12
CaO	1.71	2.10	2.03	2.17	3.75
Na_2O	7.62	3.70	5.81	3.30	4.10
K_2O	.10	2.72	1.80	4.75	3.49
H_2O at 110°	.15	.10	.11	.16	.10
H_2O above 110°	.23	.57	.68	.35	.39
TiO_2	.30	.25	.17	.28	.54
P_2O_5	.07	.09	.08	.09	.30
MnO	none	.07	none	trace	.05
SrO	trace	trace	.08	trace	trace
BaO	none	.10	.02	.08	.08
Li_2O	trace	trace	none	trace	trace
CO_2	....	.17	none	....	....
	99.99	100.09	100.28	100.28	99.91

F. Amphibole-biotite granite, Nevada Falls trail, Yosemite Valley. ntains alkali feldspar, plagioclase, quartz, amphibole, biotite, mag- tite, and apatite.

G. Biotite-granite, base of El Capitan, Yosemite Valley. Contains lkali feldspar, plagioclase, quartz, biotite, titanite, apatite, and iron xides.

H. Brown mica separated from G.

Analyses F, G, and H by William Valentine, record Nos. 1732, 1733.

I. Amphibole separated from quartz-monzonite, Tioga road, southeast of Mount Hoffman. Sp. gr. 3.203, 2.15°.

J. Mica separated from the same rock as I. Sp. gr. 3.05, 21°.

Analyses I and J by W. F. Hillebrand, record No. 1774.

Samples G to J are described by Turner in Amer. Journ. Sci., 4th series, vol. 7, p. 294.

	F.	G.	H.	I.	J.
SiO_2	66.83	71.08	35.64	47.49	35.75
Al_2O_3	15.24	15.90	18.62	7.07	14.70
Fe_2O_3	2.73	.62	5.54	4.88	4.65
FeO	1.66	1.31	14.60	10.69	14.08
MgO	1.63	.54	9.72	13.06	12.37
CaO	3.59	2.60	.90	11.92	.17
Na_2O	3.10	3.54	.38	.75	.32
K_2O	4.46	4.08	9.22	.49	9.19
H_2O at 110°	none	none	.48	....	1.03
H_2O above 110°	.56	.30	2.54	1.86	3.64
TiO_2	.54	.22	1.12	1.21	3.16
P_2O_5	.18	.10	.20	none	.03
ZrO_2	.04	.08	....	....	....
V_2O_3	....	....	....	.04	.05
Cr_2O_3	....	....	....	none	trace
MnO	.10	.15	.79	.51	.45
NiO, CoO	....	....	....	.02	.02
SrO	.03	.02	....	none	(?)
BaO	.11	.04	trace	none	.12
Li_2O	trace	trace	trace	trace	....
CO_2	trace	trace	....	....	....
Cl	.02	.02	....	....	....
F	....	....	.26	.06	.17
	100.82	100.60	100.01	100.05	99.90
Less O	....	....	.11	.02	.07
			99.90	100.03	99.83

K. Quartz-mica-diorite, Chowchilla River. See 17th Ann., Part I, p. 691. Contains plagioclase, quartz, a little orthoclase (?), brown mica, hornblende, rather abundant apatite, a little iron ore; one zircon-like crystal was noted. Analysis by W. F. Hillebrand, record No. 1461. P. R. C. 745.

L. Quartz-mica-diorite, Yaqui Creek. For the Educational Series of Rocks. Contains plagioclase, quartz, biotite, hornblende, a little pyroxene, iron ore, and apatite. Analysis by George Steiger, record No. 1643. P. R. C. 135. Described by Turner in Bull. 150, p. 339.

M. Diabase, dike 1½ miles northeast of Hornitos. See 17th Ann., Part I, p. 694. Contains plagioclase, partly labradorite, augite, brown hornblende, and iron ore. Analysis by Hillebrand, No. 1461. P. R. C. 750.

N. Igneous rock, near Cathay Hill. See 17th Ann., Part I, p. 694. Contains two minerals unidentified; neither is olivine. Analysis by Hillebrand, No. 1461. P. R. C. 749.

	K.	L.	M.	N.
SiO_2	62.62	58.09	51.32	47.75
Al_2O_3	17.51	17.46	15.28	10.56
Fe_2O_3	.49	1.12	.47	.74
FeO	4.06	5.08	8.59	8.34
MgO	2.84	4.06	7.25	19.09
CaO	5.49	6.24	11.58	9.62
Na_2O	3.49	2.94	2.92	1.32
K_2O	1.76	2.02	.22	.12
H_2O at 110°	.22	.29	.06	.05
H_2O above 110°	.92	1.45	.95	2.06
TiO_2	.55	.95	1.23	.37
P_2O_5	.12	.17	.25	.03
Cr_2O_3				.24
NiO				.07
MnO	.05	none	.16	.10
SrO	trace	.04	trace	trace
BaO	trace	.07	none	none
Li_2O	trace	none	trace	trace
CO_2		.21		
SO_3		.05		
Cl		.02		
F		trace		
C		.11		
	100.12	100.37	100.28	100.46

O. Feldspathic mica-schist, Chowchilla River. See 17th Ann., Part I, p. 691. Contains quartz, feldspar, biotite, muscovite, apatite, and specular iron. Analysis by W. F. Hillebrand, record No. 1461. P. R. C. 744.

P. Andalusite-hornfels, Yaqui Gulch. Principally quartz, andalusite, brown and white mica, black graphite-like grains, a little iron ore, and probably feldspar. Analysis by George Steiger, record No. 1643. Described by Turner in Bull. 150, p. 342. P. R. C. 135.

Q. Andalusite-schist, Chowchilla River. See 17th Ann., Part I, p. 691. Contains quartz, biotite, andalusite, sericite, a little muscovite, probably graphite, iron ore, a few garnets, and apparently chlorite. Analysis by Hillebrand, No. 1461. P. R. C. 743.

R. Chiastolite-schist, Yaqui Gulch. Contains chiastolite, sillimanite, brown mica, sericite (?), probably graphite, and clear grains which appear to be quartz and feldspar. Analysis by Steiger, No. 1643. Described by Turner in Bull. 150, p. 342. P. R. C. 135.

S. Hornfels, Agua Fria Creek. See 17th Ann., Part I, p. 691. Contains quartz, brown mica, iron ore, and plagioclase. Analysis by Hillebrand, No. 1461. P. R. C. 747.

	O.	P.	Q.	R.	S.
SiO_2	70.40	65.10	64.28	62.15	68.27
Al_2O_3	14.70	17.77	17.28	19.34	14.03
Fe_2O_3	.65	1.95	1.10	4.23	.46
FeO	2.57	3.29	5.34	2.25	4.68
MgO	1.47	1.43	2.57	1.88	2.23
CaO	1.63	1.38	1.19	1.60	3.89
Na_2O	3.17	2.25	.91	1.60	2.29
K_2O	3.46	2.45	2.93	3.07	3.35
H_2O at 110°	.19	.47	.20	.19	.08
H_2O above 110°	.91	2.49	2.72	1.79	.98
TiO_2	.51	.72	.65	.80	.57
P_2O_5	.05	.14	.27	.15	.21
MnO	.08	none	.09	trace	.04
SrO	trace	none	trace	none	trace
BaO	.09	none	.10	.04	.08
Li_2O	trace	none	trace	none	trace
SO_3		.03		.13	
Cl		trace		none	
F		.12		.22	
C	.15	1.21	.43	1.12	
	100.03	100.80	100.06	100.55	100.16
Less O		.06		.10	
		100.74		100.45	

13. THE QUICKSILVER REGION.

Rocks described by Becker in Mon. XIII. Analyses made by W. H. Melville in the San Francisco laboratory. With one exception (the serpentine from New Idria) all the rocks are from the districts north of San Francisco.

A. Pseudo-diabase, near Mount St. Helena. Contains augite, hornblende, oligoclase, albite, zoisite, ilmenite, leucoxene, and a little chlorite.

B. Pseudo-diabase, Sulphur Bank. Contains oligoclase, a little quartz, pyroxene, hornblende, ilmenite, sphene, serpentine, and chlorite.

C. Pseudo-diorite, Knoxville. Mainly actinolite, with a little white mica, chlorite, serpentine, sphene, rutile, and zircon.

D. Glaucophane-schist, Sulphur Bank. Mainly glaucophane and zoisite. Quartz, albite, muscovite, and sphene are also present.

	A.	B.	C.	D.
SiO_2	49.08	51.28	50.44	49.68
Al_2O_3	14.68	15.05	8.18	13.60
Fe_2O_3	1.95	2.42	1.06	1.86
FeO	9.63	8.01	6.29	8.61
MgO	6.69	6.07	17.63	6.26
CaO	10.09	7.08	11.55	10.97
Na_2O	4.60	4.43	2.98	3.09
K_2O	.20	.12	.50	.12
H_2O at 100°	.27	.39	.07	
H_2O above 100°	1.18	2.96	.92	3.84
TiO_2	1.72	1.33		1.31
P_2O_5	.23	.13		.21
Cr_2O_3			.48	
MnO	.15	.25	.21	.04
NiO		.10		
	100.47	99.62	100.31	99.59

E. Andesitic obsidian, Clear Lake. Shows grains of plagioclase, augite, and hypersthene. Sp. gr. 2.391.

F. Andesite (asperite), Clear Lake. Contains pyroxene, plagioclase, magnetite, and sometimes biotite. Pyroxene mostly rhombic. Sp. gr. 2.664.

G. Obsidian, south of Borax Lake. Sp. gr. 2.390.

H. Basalt, south of Burns Valley. Rich in olivine, with a microlitic groundmass of plagioclase and augite. Sp. gr. 2.380.

I. Ordinary basalt, Knoxville.

	E.	F.	G.	H.	I.
SiO_2	74.01	65.43	75.40	57.37	51.66
Al_2O_3	12.95	17.10	7.72	15.66	11.22
Fe_2O_3		2.39	1.41	2.06	7.62
FeO	1.42	1.19		4.46	
MgO	.48	1.48	1.26	8.84	13.61
CaO	.99	3.88	1.55	4.94	7.72
Na_2O	5.34	3.66	8.09	3.05	5.98
K_2O	4.65	2.83	4.52	1.51	.89
H_2O at 100°		.20	.43	.61	1.06
H_2O above 100°	.29	.36		.12	
TiO_2	.24	.83		.60	trace
P_2O_5	.01	trace		.02	
Cr_2O_3					.25
MnO	trace	.70	.12	.27	.12
NiO		.20		.41	
Cl	.07		.12		
	100.45	100.25	100.62	99.92	100.13

J. Light-green, marmolitic serpentine, New Idria.

K. Black serpentine, Sulphur Bank.

L. Light-green serpentine, Sulphur Bank.

	J.	K.	L.
SiO_2	41.54	39.64	41.86
Al_2O_3	2.48	1.30	.69
FeO	1.37	7.76	4.15
MgO	40.42	37.13	38.63
H_2O	14.18	13.81	14.16
Cr_2O_3		.29	.24
MnO		.12	.20
NiO	.04	.33	trace
	100.03	100.38	99.93

14. MOUNT DIABLO.

Described by Turner and Melville in Bull. Geol. Soc. Amer., vol. 2, pp. 383–414. Analyses by W. H. Melville. Those with record numbers were made in the Washington laboratory; the others were made in the laboratory at San Francisco.

A. Diabase, Mitchell Canyon. Composed of augite, plagioclase, and ilmenite, with uralite and chlorite secondary.

B. The same rock, partly altered and partly uralitic. Called "diabase-diorite" by Turner.

C. Pyroxenite, near Bagley Creek. Composed of bronzite and diallage. Equivalent to the websterite of North Carolina. P. R. C., 735.

D. Glaucophane-schist, Pine Canyon. Contains numerous cinnamon garnets.

A, B, and C have the record No. 1247.

	A.	B.	C.	D.
SiO_2	52.06	51.58	53.25	47.84
Al_2O_3	14.34	14.99	2.80	16.88
Fe_2O_3	2.11	2.04	.69	4.99
FeO	7.74	8.36	5.93	5.56
MgO	9.26	6.51	19.91	7.89
CaO	8.05	8.59	16.22	11.15
Na_2O	1.74	3.08	.19	3.20
K_2O	.73	.31	trace	.46
H_2O at 105°	.59	.34	.05	.17
H_2O above 105°	2.90	2.67	.24	1.81
TiO_2	.47	1.05		
P_2O_5	.13	.24		.14
Cr_2O_3			.54	
NiO			.07	
MnO	trace	trace	.09	.56
	100.12	99.76	99.98	100.65

E. Crystalline gabbro, Bagley Creek. Contains plagioclase and diallage. Record No. 1166.

F. Shaly gabbro. Friable, containing carbonates and sulphates. Somewhat resembles serpentine.

G. Shaly gabbro, like F, much resembling a true serpentine.

According to Turner, F and G are merely weathered layers of the gabbro.

	E.	F.	G.
SiO_2	47.49	45.43	45.69
Al_2O_3	15.81	12.55	13.30
Fe_2O_3	1.07	....	1.85
FeO	4.50	6.50	4.72
MgO	10.39	13.41	13.06
CaO	15.53	12.39	13.50
Na_2O	1.16	1.71	1.36
K_2O	trace	.11	trace
H_2O at 105°	1.20	2.41	2.29
H_2O above 105°	1.83	2.74	2.47
P_2O_5	trace	.04	.06
NiO	.06	....	....
MnO	.41	.21	.24
CO_2	....	2.35	1.89
SO_3	....	.24	.43
Organic matter	....	trace	....
	99.45	100.09	100.86

The following analyses are of serpentines derived from a peridotite-pyroxenite dike:

H. Almost black. Possibly derived from adjacent shale.

I. Almost black. Derived from pyroxenite.

J. Bastite. Derived from pyroxenite. Record No. 1166.

K. Friable serpentine.

	H.	I.	J.	K.
SiO_2	38.53	40.50	36.57	36.96
Al_2O_3	14.55	.78	.95	.39
Fe_2O_3	2.65	4.01	7.29	5.00
FeO	4.01	2.04	.37	2.34
MgO	21.79	37.43	40.27	33.84
CaO	3.13	.39	.14	3.81
Na_2O	.07	.28	.31	.34
K_2O	.88	.16	trace	.14
H_2O at 100°	4.51	2.81	.94	2.16
H_2O above 100°	9.56	10.94	12.43	14.02
P_2O_5	trace	trace	....	.02
Cr_2O_3	trace	.41	.33	.78
NiO	trace	.11	.31	trace
MnO	.32	.13	.10	.09
	100.00	99.99	100.01	99.89

Accidental organic matter was deducted from analyses H and I, with subsequent recalculation of the data to 100 per cent.

L. Serpentine.

M. Talc-like, yellowish-green serpentine.

N. Weathered serpentine.

O. Olive colored, probably serpentine.

Samples H, I, and J are from near Bagley Creek; K, L, M, and N from near Arroyo del Cerro; O from Ferguson ravine. M and O carry considerable chromite.

	L.	M.	N.	O.
SiO_2	34.84	32.27	41.52	30.98
Al_2O_3	.42	11.45	1.57	1.04
Fe_2O_3	6.08	trace	3.50	4.88
FeO	1.85	5.05	1.07	2.01
MgO	30.74	33.30	36.84	38.44
CaO	7.02	.41	.44	.22
Na_2O	.42	trace		.40
K_2O	.07	trace		.16
H_2O at 100°	1.67	.44	3.32	.39
H_2O above 100°	15.72	12.40	12.51	20.43
P_2O_5	.04	trace		trace
Cr_2O_3	.68	5.19		.34
NiO	trace	.19		
MnO	.01	trace	.29	.42
SO_3				.44
	99.56	100.70	101.06	100.15

15. MISCELLANEOUS ROCKS.

A. Rhyolitic obsidian, Medicine Lake, Modoc County. Collected by J. S. Diller, who reports it to be a banded obsidian, containing a few minute feldspar crystals. The banding is due to a multitude of trichites. Analysis by L. G. Eakins, record No. 1072.

B. Tuff from Hyampom, south fork of Trinity River, Trinity County. Almost wholly made up of particles of clear glass. Collected and described by Diller. Analysis by George Steiger, record No. 1427.

C. Diabase-porphyrite, one-half mile west of Browns Valley, Yuba County. Collected and described by W. Lindgren. Contains augite, plagioclase, magnetite, chlorite, and epidote. Analysis by W. F. Hillebrand, record No. 1419.

D. Amphibolitic schist, 1 mile northeast of Browns Valley, Yuba County. Collected and described by W. Lindgren. From metamorphosis of C. Contains chiefly green hornblende and feldspar. Analysis by Hillebrand, No. 1419.

	A.	B.	C.	D.
SiO_2	73.51	70.40	48.26	54.13
Al_2O_3	14.42	13.50	14.83	14.53
Fe_2O_3	.46	1.31	3.27	1.50
FeO	1.49	1.61	5.97	5.25
MgO	.33	.37	8.77	10.93
CaO	1.26	.56	11.38	4.91
Na_2O	4.03	2.11	1.57	3.53
K_2O	4.29	2.39	1.13	.32
H_2O at 100°	.40	1.05	.10	.20
H_2O above 100°		7.41	3.37	4.01
TiO_2			.51	.46
P_2O_5	.04	.08	.25	.09
MnO	trace	trace	.15	.15
SrO			trace	trace
BaO			.05	.02
Li_2O			trace	none
CO_2			1.24	
	100.23	100.79	100.85	100.03

E. Basalt, base of a lava flow, east of the head of the San Joaquin River, Madera County. Description supplied by Turner. Hitherto unpublished. Contains pyroxene, partly augite, plagioclase, olivine, and iron ores. Analysis by W. F. Hillebrand, record No. 1767.

F. Olivine-basalt, west peak of the Dardanelles, Alpine County. Described by Ransome in Bull. 89. Contains olivine, largely altered to iddingsite, plagioclase, serpentine, and augite. Analysis by George Steiger, record No. 1697.

G. Mica separated from quartz-monzonite, near Bloods Station, Alpine County. Described by Turner in Amer. Journ. Sci., 4th series, vol. 7, p. 294. Analysis by William Valentine, record No. 1736.

	E.	F.	G.
SiO_2	51.89	48.76	35.62
Al_2O_3	15.28	16.60	15.24
Fe_2O_3	3.10	5.60	4.69
FeO	3.60	5.01	13.67
MgO	8.68	6.93	12.70
CaO	7.38	8.79	.95
Na_2O	3.27	2.47	.50
K_2O	2.57	.66	7.72
H_2O, at 105°	1.17	1.49	.94
H_2O, above 105°	1.37	2.19	4.36
TiO_2	.91	1.26	2.61
P_2O_5	.61	.19	....
ZrO_2	trace	....	....
MnO	.12	none	....
NiO	.02	....	....
SrO	.09	....	trac
BaO	.15	trace	.2
Li_2O	trace	....	tra
CO_2	none	.42	......
	100.21	100.37	100

H. Scoriaceous rhyolite, Mono Craters, south of Mono Lake. Described by Russell in 8th Ann., Part I, p. 380. Analysis by T. M. Chatard, record No. 36.

I. Obsidian, Mono Lake. Analysis by W. H. Melville, record No. 1346. Described by Lindgren in Bull. 150, p. 149. P. R. C. 60.

J. Pumice, Mono Lake. Analysis by Melville, No. 1346. Described by Lindgren in Bull. 150, p. 148. P. R. C. 59.

K. Volcanic ash, east shore of Owens Lake. Collected and analyzed by Chatard, record No. 783.

	H.	I.	J.	K.
SiO_2	74.05	75.78	67.39	55.81
Al_2O_3	13.85	12.39	15.99	10.07
Fe_2O_3	trace	.22	.56	3.43
FeO	....	1.25	1.99	.67
MgO	.07	.31	.77	2.22
CaO	.90	.81	1.63	1.05
Na_2O	4.60	4.00	4.74	.75
K_2O	4.31	4.64	4.80	2.98
H_2O at 110°	2.20	.41	2.06	.65
H_2O above 110°				2.50
TiO_2	....	....	....	.80
P_2O_5	....	....	....	.27
MnO	....	....	....	.23
$CaCO_3$	....	....	....	14.44
NaCl, soluble	....	....	....	1.45
Na_2SO_4, soluble	....	....	....	.80
Na_2CO_3, soluble	....	....	....	2.09
	99.98	99.81	99.93	100.21

OREGON.

1. BASALT, MOUNT THIELSEN.

Partly described by Diller in Am. Journ. Sci., 3d series, vol. 28, p. 257. A hypersthene-basalt containing hypersthene, olivine, feldspar, and magnetite. In the printed paper only the analyses of the groundmass and the fulgurite formed in it are given.

A. Hypersthene-basalt.
B. Pyroxene.
C, D. Feldspars.
E. Groundmass.
F. A fulgurite, or lightning tube.

Analyses A and F by F. W. Clarke, record Nos. 108, 105; B, C, D, and E by T. M. Chatard, record Nos. 135, 133, 134, 128. These analyses were made early in the history of the laboratory and are by no means complete.

	A.	B.	C.	D.	E.	F.
SiO_2	55.68	53.31	55.48	51.95	55.85	55.04
Al_2O_3	18.93	5.99	26.91	28.84	22.95	
Fe_2O_3			2.32	2.24	4.59	28.99
FeO	8.73	13.43				
MgO	4.86	21.69	2.27	1.34	3.08	5.85
CaO	7.99	3.69	8.11	11.42	8.41	7.86
Na_2O	2.12	....	3.14	3.22	2.16	....
K_2O	.48	....	.72	.59	2.67	....
H_2O	.60	....	.66	.40	.52	1.11
TiO_2	....	....	.39	trace	....	....
P_2O_5	....	....	....	....	trace	....
	99.39	98.11	100.00	100.00	100.23	98.85

Iron oxides not separated. Analyses B, C, D, and F made on very small quantities of material. C and D were analyzed by the hydrofluoric acid method, and the silica was determined by difference.

2. PERIDOTITE, DOUGLAS COUNTY.

The matrix of the nickel silicate at Riddle. Described by Diller and Clarke in Bull. 60, p. 21.

The rock, which may be classed as saxonite, consists essentially of olivine and enstatite, with a little chromite and magnetite. Olivine predominates, and the enstatite forms less than one-third of the mass. Quartz, serpentine, and genthite are present as alteration products. Analyses by F. W. Clarke, record Nos. 811, 814, 792.

A. The fresh rock. P. R. C. 114.

B. Separated olivine.

C. The genthite found in the altered rock. Probably derived from olivine.

	A.	B.	C.
SiO_2	41.43	42.81	44.73
Al_2O_3	.04	....	1.18
Fe_2O_3	2.52	2.61	
FeO	6.25	7.20	....
MgO	43.74	45.12	10.56
CaO	.55	none	....
H_2O at 110°	....	....	8.87
H_2O ign	4.41	.57	6.99
Cr_2O_3	.76	.79	....
MnO	none	none	....
NiO	.10	.26	27.57
	99.80	99.36	99.90

3. CRATER LAKE.

Rocks collected by J. S. Diller. Petrographic data, hitherto unpublished, supplied by Horace B. Patton for all except the last rock in the series. Analyses A to J, inclusive, by H. N. Stokes, record No. 1671.

A. Vitrophyric rhyolite, south edge of Llao Rock flow. Contains plagioclase, hypersthene, hornblende, and apatite in a glassy groundmass crowded with augite microlites.

B. Streaked rhyolite, near "Wine Glass" Grotto Cove. Contains plagioclase, hypersthene, hornblende, and magnetite, with black glass. A few small inclusions of basalt and hypersthene-andesite.

C. Rhyolite, small dike immediately below Llao Rock. Contains plagioclase, hornblende, hypersthene, and magnetite, in a glassy groundmass crowded with microlites of feldspar and augite.

D. Rhyolite, water's edge, head of Cleetwood Cove. Contains plagioclase, hypersthene, brown hornblende, and magnetite, in a feldspathic groundmass of trachytic type.

E. Hypersthene-augite-andesite, large dike transsecting the northwestern portion of the crater rim. Contains plagioclase, hypersthene, augite, and magnetite in a groundmass having a moderate amount of glass.

F. Hypersthene-augite-andesite, west edge of Wizard Island. Same minerals as E.

	A.	B.	C.	D.	E.	F.
SiO_2	70.77	68.17	71.87	70.10	60.09	59.39
Al_2O_3	14.83	15.60	14.53	15.18	17.85	18.45
Fe_2O_3	1.35	2.31	1.28	1.78	2.03	1.79
FeO	1.25	.94	1.02	1.09	3.45	3.90
MgO	.64	1.02	.48	.74	3.50	3.13
CaO	2.12	2.76	1.59	2.27	6.28	6.29
Na_2O	5.07	5.15	5.08	5.15	4.17	4.29
K_2O	2.68	2.46	2.84	2.58	1.31	1.29
H_2O at 110°	.07	.09	.06	.10	.12	.10
H_2O above 110°	.33	.45	.22	.19	.26	.42
TiO_2	.38	.54	.41	.48	.54	.41
P_2O_5	.13	.13	.10	.13	.23	.22
ZrO_2	.05	none	.04	.04	none	none
NiO	none	none	none	none	.05	none
SrO	.02	.03	.03	.03	.05	.04
BaO	.08	.06	.08	.08	.05	.05
Li_2O	trace	trace	trace	trace	trace	trace
Cl	.11	trace	trace	.03	trace	trace
	99.88	99.71	99.63	99.97	99.98	99.77

Traces of manganese in all. Fluorine not sought for. No CO_2, S, SO_3, or Cr_2O_3 in any.

G. Hypersthene-augite-andesite, crater rim, just south of "The Watchman." Same minerals as F.

H. Hypersthene-augite-andesite, Palisades, under Round Top, northeast portion of the rim. Contains plagioclase, hypersthene, augite, and magnetite.

I. Hypersthene-augite-andesite, lake level, under Llao Rock. Same minerals as H.

J. Basalt, base of Red Cone. Contains plagioclase, augite, olivine, and magnetite, with some glass base.

K. Basalt, one mile east of the summit of the Cascade Range, on the road from Fort Klamath to Crater Lake. Described by J. S. Diller as a typical basalt, carrying a considerable amount of hypersthene. Analysis by W. F. Hillebrand, record No. 408.

	G.	H.	I.	J.	K.
SiO_2	60.98	62.09	58.41	52.99	57.47
Al_2O_3	17.82	17.03	17.85	16.71	18.86
Fe_2O_3	1.83	2.38	2.67	3.80	2.21
FeO	3.33	2.69	3.29	3.55	4.08
MgO	2.76	3.08	3.61	6.95	4.27
CaO	5.73	5.65	6.81	8.49	7.42
Na_2O	4.26	4.10	3.77	3.56	3.85
K_2O	1.43	1.67	1.23	1.29	.73
H_2O at 110°	.13	.04	.34	.18	.22
H_2O above 110°	.45	.13	.86	.59	
TiO_2	.71	.65	.69	1.18	.75
P_2O_5	.17	.19	.24	.42	.24
NiO	none	none	none	.02	....
MnO	trace	trace	trace	trace	.10
SrO	.05	.07	.05	.12	.11
BaO	.06	.07	.05	.07	.03
Li_2O	none	none	trace	none	....
Cl	trace	trace?	trace	trace	....
	99.71	99.84	99.87	99.92	100.34

4. ROCK FROM WILBUR, DOUGLAS COUNTY.

A tuff partly of igneous, partly of organic, origin. The igneous matter contains a few grains of feldspar and augite, with particles of a rock like diabase. The organic remains are partly calcareous and partly siliceous. Description supplied by J. S. Diller. Analysis by H. N. Stokes, record No. 1737.

SiO_2	55.15
Al_2O_3 [a]	9.75
Fe_2O_3	7.76
MgO	2.22
CaO	10.48
Na_2O	1.00
K_2O	.50
H_2O at 110°	2.70
H_2O above 110°	6.59
CO_2	3.64
	99.79

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[a] *Includes* TiO_2 *and* P_2O_5 *if present.*

WASHINGTON.

Rocks from the Mount Stuart quadrangle, Kittitas County. Collected by George Otis Smith, who furnishes the petrographic data. Hitherto unpublished. Analyses A, B, C, F, and G by H. N. Stokes, record No. 1836; D, E, H, and I by W. F. Hillebrand, record No. 1831.

A. Granodiorite, south slope of Mount Stuart. Contains plagioclase, orthoclase, hornblende, biotite, quartz, and magnetite.

B. Granodiorite, ridge between Hardscrabble and Cascade creeks. Contains plagioclase, orthoclase, biotite, hornblende, quartz, magnetite, and apatite.

C. Granodiorite-porphyry, dike 2 miles west of Mount Stuart. Contains plagioclase, biotite, hornblende, orthoclase, and quartz.

D. Serpentine, Three Brothers. Derived from saxonite. Contains serpentine, bastite, magnetite, and pyrite.

E. Metamorphic rock, head of Beverly Creek. Believed to be derived from an inclusion of limestone in the peridotite.

	A.	B.	C.	D.	E.
SiO_2	64.04	63.37	63.78	39.00	32.12
Al_2O_3	15.58	15.90	16.39	1.75	.82
Fe_2O_3	1.26	1.41	1.12	5.16	2.05
FeO	3.22	3.18	2.76	1.71	3.50
MgO	3.23	3.33	3.27	38.00	26.73
CaO	4.51	4.63	4.07	trace	1.81
Na_2O	4.01	4.05	3.84	.10	.06
K_2O	2.22	2.10	2.03		
H_2O at 110°	.19	.18	.22	1.31	.43
H_2O above 110°	1.17	1.16	1.82	12.43	.98
TiO_2	.69	.69	.44	trace	trace
P_2O_5	.16	.17	.11	trace	trace
Cr_2O_3	none	none	none	.47	.27
NiO	none	none	none	.10	.08
MnO	trace	trace	.05	.15	.14
SrO	trace	none	trace	none	none
BaO	.11	.06	.08	none	none
Li_2O	trace	trace	trace	none	...
CO_2	none	none	none	none	31.04
S	trace	trace	trace	...	...
FeS_2 [a]	...	...	...	.03	none
	100.39	100.23	99.98	100.21	100.03

[a] Actual condition of sulphur not known.

F. Gabbro, east of Beverly Creek. Contains diallage and "basic" plagioclase, with pyrite and serpentine as alteration products.

G. Olivine-diabase, Camas Land. Contains augite, olivine, plagioclase, magnetite, and apatite.

H. Diabase, dike on ridge west of Turnpike Creek. Contains plagioclase, augite, olivine, magnetite, and apatite.

I. Basalt, middle fork of Teanaway River. Contains augite, plagioclase, magnetite, and apatite, with a glassy base.

	F.	G.	H.	I.
SiO_2	48.58	51.98	57.21	53.35
Al_2O_3	20.23	15.99	12.99	12.90
Fe_2O_3	1.26	3.10	3.28	2.64
FeO	3.02	5.88	10.18	11.28
MgO	7.59	5.09	1.59	2.68
CaO	14.01	9.68	5.97	6.96
Na_2O	2.25	2.71	3.07	2.83
K_2O	.19	.81	1.61	1.40
H_2O at 110°	.28	.48	.68	.91
H_2O above 110°	2.68	2.08	1.03	1.76
TiO_2	.09	1.71	1.72	2.44
P_2O_5	trace	.31	.44	.45
Cr_2O_3	trace	none	none	none
V_2O_3			none	.04
MnO	trace	.10	.24	.25
NiO	none	none	trace	trace
SrO	none	none	trace	trace
BaO	none	.03	.06	.05
Li_2O	none	trace	trace	trace
FeS_2			.13	.13
S	.10	.01		
	100.25	99.96	100.20	100.07

ALASKA.

Rocks A to H, inclusive, were collected by G. F. Becker, who furnishes the petrographic data. A, B, C, D, F, and H are described by Becker in the 18th Ann., Part 3, p. 7. Analyses by Hillebrand, record No. 1585.

A. Augite-bronzite-andesite, Delarof Harbor, Unga Island. Greenish black. Contains plagioclase, near labradorite, with much smaller proportion of augite and bronzite, in a groundmass of plagioclase, with a little glass and much light-green indeterminate material. Contains 0.04 V_2O_3.

B. Augite-bronzite-andesite, St. Augustine Volcano, Cook Inlet. Purplish gray. Contains labradorite, augite, and bronzite, in a groundmass of plagioclase and magnetite.

C. Quartz-porphyry, bed of Bear Creek, 4 miles from its mouth, Turnagain Arm, Cook Inlet. Resembles D, with more feldspar and less quartz.

D. Quartz-porphyry, east of mouth of Indian River, Sitka, Baranof Island. Contains plagioclase, quartz, a little pyroxene, and some carbonaceous matter, with secondary quartz, calcite, and muscovite.

E. Diorite, head of Captains Bay, Unalaska Island. Contains plagioclase, biotite, hornblende, chlorite, magnetite, and sometimes tourmaline.

	A.	B.	C.	D.	E.
SiO_2	56.63	60.40	62.92	65.94	58.63
Al_2O_3	16.85	16.89	14.29	13.74	16.23
Fe_2O_3	3.62	1.88	.84	.49	1.91
FeO	3.44	3.72	4.66	5.21	4.20
MgO	4.23	3.82	3.14	2.33	4.28
CaO	7.53	7.25	2.72	2.87	6.59
Na_2O	3.08	3.80	4.30	2.80	3.51
K_2O	2.24	.77	1.39	1.63	2.09
H_2O at 110°	.80	.09	.22	.21	.15
H_2O above 110°	.51	.20	2.84	2.59	1.17
TiO_2	.67	.61	.84	.80	.74
P_2O_5	.16	.16	.13	.21	.20
NiO	trace?	.02	trace	trace?	.02
MnO	.23	.12	.15	.11	.11
SrO	trace	trace	trace	trace?	trace
BaO	.09	.06	.10	.12	.06
Li_2O	trace	trace	trace	trace	trace
CO_2	none	none	1.24	.59	none
C	....	....	....	.20	....
FeS_2	.06	.08	.32	.41	.04
	100.14	99.87	100.10	100.25	99.93

F. Diorite, Karluk Cliffs, Kadiak Island. Contains labradorite and hornblende, with subordinate quartz, biotite, and magnetite.

G. Diorite, Lane and Hayward mine, Silver Bow Basin. Contains plagioclase, biotite, hornblende, and scattering grains of quartz, with secondary chlorite, epidote, and muscovite.

H. Diorite, Treadwell mine, Douglas Island. Contains plagioclase, mostly albite, with secondary quartz, calcite, and pyrite, the latter apparently replacing ferromagnesian silicates. Contains 0.01 V_2O_3.

I. Hornblende-andesite, Bogoslof Island. Described by Merrill in Proc. U. S. National Museum, vol. 8, p. 31. Contains hornblende, augite, plagioclase, tridymite, grains of iron ore, a little apatite, and probably sanidine. P. R. C. 315.

J. Like I, but darker colored. Contains more hornblende, no glass, and little or no tridymite. Same locality, also described by Merrill. Analyses I and J, by T. M. Chatard, record Nos. 209, 210. P. R. C. 316.

	F.	G.	H.	I.	J.
SiO_2	61.58	54.20	63.01	56.07	51.54
Al_2O_3	15.89	15.86	18.48	19.06	20.31
Fe_2O_3	2.19	3.32	.06	5.39	4.64
FeO	5.50	4.14	.32	.92	3.56
MgO	2.69	3.51	.06	2.12	3.16
CaO	6.49	5.32	2.66	7.70	9.55
Na_2O	3.04	3.28	10.01	4.52	4.29
K_2O	.51	3.30	.39	1.24	2.47
H_2O at 110°	.16	.55	.05	.99	.34
H_2O above 110°	1.26	2.40	.27		
TiO_2	.63	1.35	.13	1.24	.32
P_2O_5	.12	.68	.06	.16	.57
NiO	trace ?	.02	none	....	....
MnO	.20	.19	.06	.23	.32
SrO	trace ?	.04	trace	....	....
BaO	.06	.41	.02	....	....
Li_2O	trace	trace	none	....	....
CO_2	none	1.45	2.01	....	....
FeS_2	.06	.26	2.10	....	....
	100.38	100.28	99.69	99.64	101.07

Rocks K to S. Collected by J. E. Spurr, who furnishes the petrographic notes. All but S are to appear in the 21st annual. Analyses by Stokes, record Nos. 1809 and 1822.

K. Alaskite, Chilkoot Pass. Dike in granite. Contains quartz, orthoclase, and some twinned feldspars, accessory zircon, actinolite, magnetite, and siderite.

L. Alaskite-porphyry, Fortymile Creek, near Canyon Creek. Dike. Contains quartz, orthoclase, and some plagioclase, with accessory biotite and epidote.

M. Alaskite, Skwentna River, 12 miles above its mouth. Dike. Contains quartz, orthoclase, and microcline, with no dark minerals.

N. Alaskite, Tordrillo Mountains. Dike. Consists of quartz, orthoclase, and microcline, with no dark minerals.

	K.	L.	M.	N.
SiO_2	76.30	67.01	75.01	77.33
Al_2O_3	12.50	17.91	13.88	12.55
Fe_2O_3	1.47	1.30	.74	.91
FeO				
MgO	none	.42	.09	.10
CaO	.17	1.86	1.00	.17
Na_2O	3.86	5.33	3.52	3.19
K_2O	4.67	4.56	4.89	4.80
H_2O at 110°	.18	.16	.11	.15
H_2O above 110°	.32	.48	.26	.53
TiO_2	.05	.10	.06	.09
BaO	.07	.60	.10	trace
SrO	none	.13	trace	trace
Li_2O	none	none	trace	trace
	99.59	99.86	99.66	99.82

In K to N there are traces of P_2O_5 but no CO_2. Manganese is also present in traces.

O. Andesite-oligoclase-scapolite-biotite rock, Skwentna River, miles above its mouth. Dike. Essential constituents andesine-olig lase, scapolite, and biotite, with accessory apatite and zircon.

P. Augite-belugite, Skwentna River, near Hayes River. Dike. Co tains essential feldspar, intermediate between andesine and labradorite ugite, and some hornblende. Also a considerable amount of pyrite.

Q. Tordrillite, Tordrillo Mountains. Dike. Contains phenocrysts of quartz, orthoclase, anorthoclase, and anorthoclase-albite. Groundnass consists of quartz and orthoclase. No dark minerals except very small quantities of secondary hornblende.

R. Augite-aleutite, near Kalinai Pass, Aleutian Peninsula. Lava. Chiefly labradorite, tending toward andesine, with a considerable amount of pale-green augite.

S. Tonalite-aplite, Yukon River, above Fort Hamlin. Dike. Consists essentially of quartz and soda-lime feldspars.

	O.	P.	Q.	R.	S.
SiO_2	62.78	50.23	75.84	56.03	74.79
Al_2O_3	17.16	19.46	13.38	18.31	12.59
Fe_2O_3	1.96	4.21	1.45	3.47	1.19
FeO	2.31	4.20		4.42	
MgO	2.32	3.59	.10	3.64	.31
CaO	4.84	10.39	.07	7.43	3.58
Na_2O	4.11	3.08	3.33	3.60	5.10
K_2O	2.15	1.32	4.73	1.18	.21
H_2O at 110°	.24	.16	.18	.12	.09
H_2O above 110°	.88	1.01	.71	.31	1.03
TiO_2	.56	1.30	.09	1.24	.17
P_2O_5	.15	.41	trace	.13	trace
MnO	.06	.07	trace	.11	trace
BaO	.04	.04	trace	trace	none
SrO	trace	trace	trace	trace	none
Li_2O	trace	trace	trace	trace	none
CO_2	none	.25	none	none	.58
S (a)	.02	.02		trace	
l	trace				
	99.58	99.74	99.88	99.99	99.64

a Whether S or SO_3 was not determined.

BRAZIL.

A kyanitic schist from Serra do Gigante, near Diamantina, was analyzed at the request of Prof. O. A. Derby, who describes the rock in Amer. Journ. Sci., 4th ser., vol. 7, p. 343. Analysis by Hillebrand, record No. 1783. Contains kyanite, chlorite, sericite, quartz, and rutile.

A. Bulk analysis of the schist.

B. Portion soluble in hydrochloric acid.

C. Portion soluble in strong sulphuric acid.

D. Residue insoluble in sulphuric acid.

The bracketed figures are deduced from other columns than the one in which they appear.

	A.	B.	C.	D.
SiO_2	38.32	10.78	14.76	[23.56]
Al_2O_3	28.16	10.42	14.77	[13.39]
Fe_2O_3	2.24	[1.78]	[2.24]	none
FeO	4.02	[3.21]	[4.02]	none
MgO	12.04	9.34	[12.04]	none
CaO	.32	.34	.32	....
Na_2O	.16	[.03]	[.03]	.13
K_2O	1.11	.26	[.26]	.85
H_2O at 105°	.55	[.55]	[.55]	....
H_2O above 105°	7.46	5.36	6.80	.66
TiO_2	4.93	.10	.20	[4.73]
P_2O_5	.47	.47	.47	....
ZrO_2	.09	trace	(?)	[.09]
CoO, NiO	.04	(?)	[.04]	....
MnO	.16	(?)	[.16]	....
SrO	trace	(?)	(?)	....
Li_2O	trace	trace	trace	trace
S	trace	....	....	....
F	trace?	....	....	....
	100.07	42.64	56.66	43.41

STONY METEORITES.

1. ROCKWOOD, TENNESSEE.

From the Crab Orchard Mountains, Cumberland County, Tennessee, about 8½ miles west of Rockwood. Analyzed by J. E. Whitfield, record No. 735, and described by him in Bull. 60, p. 103.

A. Analysis of the material as a whole.

B. Nickel-iron separated. Forms not over 16 per cent of the mass.

C. Nodule from meteorite.

D. Portion of nodule, 94 per cent, insoluble in hydrochloric acid. May be enstatite.

The stony part of the meteorite appears to be mainly pyroxene and anorthite. Fe_2O_3 was not determined, and FeO represents the total iron oxide.

	A.	B.	C.	D.
SiO_2	41.92	....	49.96	51.85
Al_2O_3	9.27	....	4.75	4.52
FeO	22.94	....	15.97	13.26
CaO	9.09	....	1.15	1.09
MgO	8.76	....	28.15	29.28
Fe	3.75	87.59	....	....
Ni	1.74	12.09	....	....
Co	trace	trace	....	....
Cu	trace	trace	....	....
P	.65	....	....	....
S	1.58	....	....	....
Cl	.18	....	....	....
	99.88	99.68	99.98	100.00

2. HAMBLEN COUNTY, TENNESSEE.

Mass of about half and half stone and iron found about 6 mil WSW. of Morristown. Analyzed by L. G. Eakins, and described Bull. 113, p. 61.

A. The nickel-iron.

B. The part of the stony portion soluble in hydrochloric acid; 37. per cent, recalculated to 100, with sulphur deducted.

C. Insoluble part of the stony portion; 62.10 per cent, recalculat to 100.

A petrographic description of this meteorite is given by Merrill Amer. Journ. Sci., 4th series, vol. 2, p. 149, together with an analy of the feldspar. He finds it to contain, in addition to the nickel-iro enstatite, diallage, anorthite, olivine or monticellite, oldhamite or se ondary gypsum derived from oldhamite, lawrenceite, troilite, a schreibersite.

	A.		B.	C.
Fe	90.92	SiO_2	45.61	50.67
Ni	7.71	Al_2O_3	22.62	14.89
Co	.80	Cr_2O_3		1.32
Cu	trace	FeO	11.73	10.55
P	.19	NiO	1.06	
S	.04	MnO		.76
	99.66	CaO	14.09	3.61
		MgO	3.64	17.98
		K_2O		.03
		Na_2O		.19
		P_2O_5	1.25	
		S		
			100.00	100.00

3. WINNEBAGO COUNTY, IOWA.

Fell May 2, 1890. Sp. gr. 3.804, 28°.5. Analyzed by L. G. Eakins, record No. 1190, and described in Bull. 78, p. 95.

Composition of the mass.

Nickel-iron	19.40
Troilite	6.19
Soluble silicates	36.04
Insoluble silicates	38.37
	100.00

Separate analyses:

A. The nickel-iron.

B. Silicate soluble in hydrochloric acid, calculated to 100 per cent.

C. Insoluble silicate, recalculated to 100 per cent. The Cr_2O_3 probably represents chromite.

	A.		B.	C.
Fe	92.65	SiO_2	39.74	55.51
Ni	6.11	Al_2O_3		5.43
Co	.65	Cr_2O_3		.25
P	trace	FeO	18.42	9.45
S	trace	NiO	.38	
	99.41	MnO	trace	
		CaO	.69	3.00
		MgO	40.77	24.09
		K_2O	trace	.15
		Na_2O	trace	2.12
		P_2O_5	trace	
			100.00	100.00

4. TANEY COUNTY, MISSOURI.

Analysis by J. E. Whitfield, record No. 736. See Bull. 60, p. 10
Sp. gr., 4.484.

A. The separated nickel-iron.
B. The stony portion as a whole.
C. Silicates soluble in hydrochloric acid, recalculated to 100 per cen
D. Insoluble silicates, recalculated to 100 per cent.

	A.		B.	C.	D.
Fe	89.41	SiO_2	45.88	26.95	52.39
Ni	10.41	Al_2O_3	7.89	17.69	7.11
Co	.29	FeO	19.73	35.98	14.68
P	.16	CaO	6.02	15.98	4.49
	100.27	MgO	17.96	3.40	21.33
		NiS	1.67	....	....
		FeS	.54	....	....
			99.69	100.00	100.00

5. WASHINGTON COUNTY, KANSAS.

Fell July 25, 1890. Analyzed by L. G. Eakins, record No. 1227, an described in Bull. 90, p. 45. Sp. gr. 3.49, 21.6°.

Composition of the mass.

Nickel-iron	7.7
Troilite	5.0
Soluble silicates	46.0
Insoluble silicates	41.5
	100.2

Separate analyses.

A. The nickel-iron.
B. Silicates soluble in hydrochloric acid, calculated to 100 per cen
C. Insoluble silicates, calculated to 100 per cent.

	A.		B.	C.
Fe	86.76	SiO_2	38.50	53.80
Ni	12.18	Al_2O_3	....	4.32
Co	.83	Cr_2O_3	....	1.41
	99.77	FeO	23.54	11.98
		NiO	.69	....
		CoO	trace	....
		MnO	.34	trace
		CaO	.12	4.08
		MgO	36.81	22.37
		K_2O	....	.27
		Na_2O	....	1.77
			100.00	100.00

6. KIOWA COUNTY, KANSAS.

A pallasite found in Brenham Township. Analyzed by L. G. Eakins, record No. 1188, and described in Bull. 78, p. 94.

A. The nickel-iron, Sp. gr. 7.93, 23.4°.

B. The pure olivine. Sp. gr. 3.376, 23.2°.

C. Dark outer zone of olivine, containing troilite.

	A.		B.	C.
Fe	88.49	SiO_2	40.70	34.14
Ni	10.35	Al_2O_3	trace?	....
Co	.57	Fe_2O_3	.18	....
Cu	.03	FeO	10.79	23.20
P	.14	NiO	.02	trace
S	.08	CoO	....	.03
Si	trace?	MnO	.14	.09
C	trace	MgO	48.02	40.19
	99.66	S	....	5.42
			99.85	103.07
		Less O=S	....	2.71
				100.36

7. TRAVIS COUNTY, TEXAS.

Analyzed by L. G. Eakins, record No. 1097, and described in Bull. 78, p. 91. Sp. gr. 3.543, 20°. According to Cross, the stony portion contains olivine and enstatite, with a small amount of a colorless mineral, which is probably feldspar. Chromite is also present.

Approximate composition of the mass.

Nickel-iron	2.23
Troilite	5.03
Soluble silicates	39.84
Insoluble silicates	52.42
	99.52

A. Total analysis.
B. Nickel-iron.
C. Silicates soluble in hydrochloric acid, calculated to 100 per cent.
D. Insoluble silicates, calculated to 100 per cent.

	A.	B.	C.	D.
SiO_2	44.75		38.13	56.14
Al_2O_3	2.72		2.58	3.73
Cr_2O_3	.52			1.00
CuO	trace			
FeO	16.04		19.76	9.15
Fe	1.83	88.74		
NiO	.52		1.19	
Ni	.22	10.68		
Co	.01	.58		
MnO	trace			
CaO	2.23		1.02	3.59
MgO	27.93		37.32	24.44
K_2O	.13		undet.	.19
Na_2O	1.13		undet.	1.76
P_2O_5	.41			
S	1.83			
H_2O	.84			
	101.11	100.00	100.00	100.00
Less O = S	.92			
	100.19			

8. BLUFF, FAYETTE COUNTY, TEXAS.

Analyzed by J. E. Whitfield, record No. 824, and described in Bull. , p. 107. Sp. gr. 3.510. Examined microscopically by G. P. Merrill, ho reports, in addition to nickel-iron and pyrrhotite, olivine, enstatite, d what appears to be augite or an allied pyroxene. See Amer. Journn. i., 3d series, vol. 36, August, 1888.

A. Total analysis.

B. Nickel-iron (5.67 per cent of total).

C. Part soluble in hydrochloric acid, calculated to 100 per cent (60.62 r cent of total).

D. Insoluble part, calculated to 100 per cent (33.3 per cent of total).

	A.	B.	C.	D.
SiO_2	37.70		33.59	49.64
Al_2O_3	2.17		1.34	4.12
FeO	23.82		31.12	15.56
Fe	4.41	82.42		
NiO	1.59		2.66	trace
Ni	.88	15.44		
CoO	.16		.27	trace
Co	.37	2.14		
MnO	.45		.43	.54
CaO	2.20		1.00	4.93
MgO	25.94		28.08	25.21
P_2O_5	.25		.42	
S	1.30		2.18	
	101.24	100.00	101.09	100.00
Less O=S	.65		1.09	
	100.59		100.00	

This meteorite also contained a dark vein of sp. gr. 3.585, which carried 2.30 per cent of metallic iron. Analyses, made on less than 0.4 gramme of material, gave as follows, recalculated to 100 per cent:

E. Soluble in hydrochloric acid, metal deducted.

F. Insoluble.

	E.	F.
SiO_2	27.63	56.52
Al_2O_3	2.41	1.51
FeO	34.31	12.35
NiO+CoO	3.27	4.09
CaO	trace	trace
MgO	32.12	25.53
S	.52	
	100.26	100.00
Less O=S	.26	
	100.00	

A represents 51 per cent and F 44 per cent of the vein.

9. SAN BERNARDINO COUNTY, CALIFORNIA.

Found in the San Emigdio Mountains. Analyzed by J. E. Whitfield, record Nos. 804 and 936, and described in Bull. 60, p. 114. In fragments, badly altered.

Approximate composition of the mass.

Nickel-iron	6.21
Soluble silicates, etc	51.26
Insoluble silicates	42.23
	99.70

The soluble part was probably olivine and pyrrhotite, with secondary iron oxide. The insoluble part was enstatite, essentially.

A. The nickel-iron.

B. The enstatite.

	A.
Fe	88.25
Ni	11.27
Co	.48
	100.00

	B.
SiO_2	54.42
FeO	14.03
CaO	2.46
MgO	29.11
	100.02

10. BEAVER CREEK, BRITISH COLUMBIA.

Fell May 26, 1893, near Beaver Creek, West Kootenai district. Described by Howell, Hillebrand, and Merrill in Amer. Journ. Sci., 3d series, vol. 47, p. 430.

Composition of the mass.

Nickel-iron	17.13
Magnetite	.16
Troilite	5.05
Soluble silicates and phosphate	37.23
Insoluble silicates and chromite	40.43
	100.00

According to Merrill, the silicates visible are olivine, enstatite, probably a little plagioclase, and some glassy base.

Analyses by W. F. Hillebrand, record No. 1444.

A. Nickel-iron.

B. Nonmagnetic, stony portion.

C. Portion of B soluble in hydrochloric acid, calculated to 100 per cent.

D. Insoluble portion, calculated to 100 per cent. From C and D troilite and chromite are excluded. The chromite forms about 0.75 per cent of the stony matter.

	A.		B.	C.	D.
Fe	90.68	SiO_2	45.87	38.26	57.75
Ni	8.80	TiO_2	.09		.18
Co	.49	Al_2O_3	2.30	.56	4.89
Cu	.03	Cr_2O_3	.51		
	100.00	FeO	12.68	19.52	8.02
		Fe	3.87		
		NiO	.07	.09	trace
		MnO	.26	.27	.35
		CaO	1.96	1.03	3.44
		MgO	28.24	38.74	23.19
		K_2O	.15	.02	.25
		Na_2O	.98	.13	1.87
		H_2O	.34	.70	.06
		P_2O_5	.30	.68	
		S	2.21		
		Cl	trace	trace	
			99.83	100.00	100.00
		Troilite	6.08		
		Chromite	.75		

11. LLANO DEL INCA, CHILE.

Analyzed by L. G. Eakins, record No. 1201, and described in Bull. 78, p. 97.

Approximate composition of the mass.

Nickel-iron	25.8
Troilite	10.6
Soluble silicates	30.9
Insoluble silicates	32.6
	99.9

Separate analyses.

A. The nickel-iron.

B. Silicates soluble in hydrochloric acid, calculated to 100 per cent.

C. Insoluble silicates, calculated to 100 per cent.

Is the P_2O_5 in B derived from schreibersite?

	A.		B.	C.
Fe	89.77	SiO_2	28.08	53.11
Ni	9.17	Al_2O_3	12.74	2.32
Co	.61	Cr_2O_3		.90
	99.55	FeO	42.52	18.82
		NiO	2.90	
		MnO	.20	
		CaO	9.33	1.75
		MgO	1.98	23.10
		P_2O_5	2.25	
			100.00	100.00

METEORIC IRON.

A. The Mount Joy meteorite, found near Two Taverns post-office, near Gettysburg, Pennsylvania. Analysis by L. G. Eakins, record No. 1318.

B. From Pulaski County, Virginia. Sp. gr. 7.95, 23°. Analysis by Eakins, No. 1228. Described by Eakins in Bull. 90, p. 45.

C. From Ellenboro, Rutherford County, North Carolina. Described and analyzed by Eakins, Bull. 78, p. 93. Record No. 1160.

D. From Linnville Mountain, North Carolina. Analyzed by J. E. Whitfield, record No. 822, and described in Bull. 60, p. 107. Sp. gr. 7.778.

E. From Cherokee County, Georgia. Analysis by H. N. Stokes, record No. 1527.

	A.	B.	C.	D.	E.
Fe	93.80	93.59	88.05	84.56	91.96
Ni	4.81	5.56	10.37	14.95	6.70
Co	.51	.53	.68	.33	.50
Cu	.005	trace	.04	....	.03
P	.19	.27	.21	trace	.11
S	.01	.01	.08	.12	.01
Si	....	trace	.02	none	trace
C	....	....	....	trace	trace?
	90.325	99.96	99.45	99.96	99.31

F. From near Holland's store, Chattooga County, Georgia. Analysis by J. E. Whitfield, record No. 765. See Bull. 60, p. 106. Sp. gr. 7.801.

G. From Hamilton County, Texas. Sp. gr. 7.95, 27°. Analysis by L. G. Eakins, record No. 1189. See Bull. 78, p. 95.

H. From near Scottsville, Allen County, Kentucky. Analysis by Whitfield, record No. 509. See Bull. 55, p. 64.

I. Fell 6 miles east of Cabin Creek, Johnson County, Arkansas, March 27, 1886. Analysis by Whitfield, record No. 505. See Bull. 55, p. 63.

J. From near Grand Rapids, Michigan. Sp. gr. 7.87. Analysis by R. B. Riggs, record No. 296. See Bull. 42, p. 94.

	F.	G.	H.	I.	J.
Fe	94.60	86.54	94.32	91.87	88.71
Ni	4.97	12.77	5.01	6.60	10.69
Co	.21	.63	trace	trace	
Cu		.02			.07
Mg					.02
Mn				trace	
P	.21	.16	.16	.41	.26
S	trace	.03	.34	.05	.03
Si			none		
C	trace	.11	.12	.15	.13
Insoluble				.34	
	99.99	100.26	99.95	99.42	99.91

K. The El Capitan iron, from near Bonito, New Mexico. Analysis by H. N. Stokes, record No. 1527.

L. From La Bella Roca, Sierra de San Francisco, Mexico, State of Durango. Analysis by J. E. Whitfield, record No. 1037. Bull. 64, p. 28.

M. Troilite nodule from L, outer part, somewhat altered.

N. Troilite nodule M, inner part. Analyses L and M also by Whitfield, record No. 1037.

O. From Puquios, Chile. Sp. gr. 7.93, 25.2°. Analysis by L. G. Eakins, record No. 1181. See Bull. 78, p. 95.

P. The Abert iron, of unknown origin. Analysis by R. B. Riggs, record No. 356. Sp. gr. 7.89. See Bull. 42, p. 94.

	K.	L.	M.	N.	O.	P.
Fe	90.51	91.48		9.37	88.67	92.07
Ni	8.40	7.92			9.83	7.01
Co	.60	.22			.71	.66
Cu	.05				.04	
P	.24	.21			.17	.08
S	trace	.21			.09	.01
Si					trace?	
C		.06			.04	.05
NiS			2.07	2.13		
FeS			37.51	85.27		
Fe_2O_3			37.80			
Moisture			19.85			
	99.80	100.10	97.23	96.77	99.55	99.88

The two following meteoric irons were analyzed by L. G. Eakins in the Denver laboratory.

A. Found near Albuquerque, New Mexico. Described by Eakins in Proc. Colorado Sci. Soc., vol. 2, p. 14.

B. From Wyoming. Partial analysis.

	A.	B.
Fe	88.76	89.26
Ni	9.86	5.94
Co	.51	.78
Cu	.034	
Zn	.03	
Mn	trace	
P	.182	.24
S	.012	
Si	.044	
C	undet.	
	99.432	96.22

SANDSTONES, CHERTS AND SINTERS.

SANDSTONES FROM OHIO.

A. Blue sandstone from near Cleveland. Analysis by T. M. Chatard, record No. 214.

B. Sandstone from Berea. Analysis by L. G. Eakins, record No. 914.

C, D, E. Three samples of the "Peebles-Henley sandstone," from Portsmouth. Analyses by H. M. Stokes, record No. 1239. Alkalies, etc., undetermined.

	A.	B.	C.	D.	E.
SiO_2	91.67	92.91	90.40	89.32	87.12
Al_2O_3	6.92	3.78	5.15	5.52	5.96
Fe_2O_3	trace	trace	.65	.87	.85
FeO		.91	.27	.35	.85
MgO	.34	trace	.28	.51	.73
CaO	.28	.31			
Na_2O		.34			
K_2O		.61			
H_2O	1.17	1.19	.99	1.49	2.00
	100.38	100.05	97.74	98.06	97.51
Insol. in HCl	97.50		98.00	96.90	95.52

SANDSTONES FROM CALIFORNIA.

1. SANDSTONES FROM MOUNT DIABLO.

Described by Turner and Melville in Bull. Geol. Soc. Amer., vol. 2, pp. 383–414. Analyses made by W. H. Melville in the San Francisco laboratory.

A. Upper Cretaceous, Chico sandstone. Light brown, finely granular, carrying grains of mica and feldspar.

B. Lower Cretaceous, Neocomian sandstone. Hard, granular, greenish. From head waters of Bagley Creek.

C. Miocene sandstone. Granular, particles light brown and black, friable. From near Wall Point.

D. Chico sandstone. Greenish gray, compact, crystalline.

	A.	B.	C.	D.
SiO_2	73.71	56.84	44.54	36.93
Al_2O_3	10.40	11.37	12.63	7.22
Fe_2O_3	3.89	1.46	2.50	1.59
FeO	1.88	4.95	3.08	2.95
MgO	1.62	3.10	5.55	2.34
CaO	.96	7.62	14.65	29.34
Na_2O	3.48	3.26	3.35	2.94
K_2O	.99	.86	1.37	.64
H_2O at 100°	1.06	1.45	1.43	.57
H_2O above 100°	2.60	3.34	2.25	3.45
P_2O_5	none	.10	.29	.16
MnO	.17	.22	.44	.57
CO_2	none	5.10	7.76	[a] 11.30
	100.76	99.67	99.84	100.00

[a] CO_2 determined by difference.

Traces of organic matter are found in all four sandstones, but were not determined.

2. SANDSTONE DIKES IN SHASTA COUNTY.

Described by J. S. Diller in Bull. Geol. Soc. Amer., vol. 1, p. 411. The rock is made up of quartz, feldspar, and biotite, with a calcite cement. Serpentine, sphene, magnetite, and zircon also occur in it, but are less common.

A. From Salt Creek, one half mile above McNett's.

B. One and one-fourth miles below Ono Bridge, north fork of Cottonwood.

C, D. Three-fourths of a mile below John Allen's, Dry Creek.

E. From John Allen's, Dry Creek.

Analyses A and B by T. M. Chatard, record No. 1106; C, D, and E by J. E. Whitfield, record Nos. 972, 973.

	A.	B.	C.	D.	E.
SiO_2	48.13	48.10	59.10	61.60	54.55
Al_2O_3	11.19	12.16	14.02	12.15	10.64
Fe_2O_3	1.25	1.02	3.16	2.09	1.59
FeO	1.47	2.14	1.42	3.30	1.16
MgO	2.22	1.65	1.72	2.33	1.29
CaO	16.39	15.88	9.35	6.92	14.30
Na_2O	2.29	2.46	2.21	2.16	2.60
K_2O	1.17	1.56	1.49	1.41	1.68
H_2O at 110°	.78	.46	....	....	....
H_2O at red heat	1.78	3.27	2.63	3.10	1.60
TiO_2	.24	.47	.70	trace	trace
P_2O_5	.14	.13	trace	.08	.10
MnO	.29	.26	trace	trace	1.53
BaO	.04	undet.	....	....	....
CO_2	12.73	10.36	4.65	5.05	9.05
SO_3	....	....	trace	.27	.10
Cl	....	....	trace	trace	.72
	100.11	99.92	100.45	100.46	100.31

The following bedded sandstones of the same region are also described:

F. From middle fork of Cottonwood, 1 mile above Miller's.

G. Top of cascade, 1½ miles up Byron Creek from north fork of Cottonwood.

H. Two and one-half miles above John Allen's, Dry Creek.

Analyses F and G by Chatard, record No. 1106; H by Whitfield, record No. 974.

	F.	G.	H.
SiO_2	55.85	67.62	60.74
Al_2O_3	13.20	13.63	10.25
Fe_2O_3	2.56	1.25	4.31
FeO	4.77	3.27	6.21
MgO	1.90	2.34	3.69
CaO	6.93	2.80	4.97
Na_2O	2.60	2.78	1.83
K_2O	1.89	1.11	.52
H_2O at 110°	1.13	.64	
H_2O at redness	2.99	2.83	4.36
TiO_2	.76	.48	.86
P_2O_5	.18	.08	trace
MnO	.24	.15	trace
BaO	undet.	.03	
CO_2	4.97	.72	2.29
SO_3			.40
Cl			trace
	99.97	99.73	100.43

3. SANDSTONE FROM SULPHUR BANK.

Described by Becker in Mon. XIII, p. 92. Analysis made by Melville in the San Francisco laboratory. An altered sandstone, showing grains of quartz, plagioclase, and orthoclase.

SiO_2	68.50	H_2O at 100°	.28
Al_2O_3	12.82	H_2O above 100°	2.11
Fe_2O_3	1.29	TiO_2	.60
FeO	3.37	P_2O_5	.16
MgO	2.21	MnO	.02
CaO	1.82		100.47
Na_2O	6.03		
K_2O	1.26		

MISCELLANEOUS SANDSTONES.

A. Triassic sandstone from the Jaittelle quarry, near Hancock, Maryland. Hard, compact, brown. Analysis by F. W. Clarke, record No. 613.

B. Brown sandstone, Hummelstown, Pennsylvania. Analysis by E. A. Schneider, record No. 1280. Described by Diller in Bull. 150, p. 77. P. R. C. 14.

C. Yellow sandstone from Stony Point, Michigan. Analysis by F. W. Clarke, record No. 213.

D. Carboniferous sandstone adjoining the peridotite dike of Elliott County, Kentucky. See Diller, Amer. Journ. Sci., 3d series, vol. 32, p. 125. Analysis by T. M. Chatard, record No. 354.

E. Yellow sandstone, Armejo quarry, Colorado. Analysis, partial, by T. M. Chatard, record No. 289.

	A.	B.	C.	D.	E.
SiO_2	76.43	88.13	84.57	60.78	81.27
Al_2O_3	17.78	5.81	5.90	10.54	9.81
Fe_2O_3		1.77	6.48	3.27	1.44
FeO	....	.31	....	....	....
MgO	.92	.53	.68	1.59	.42
CaO	.84	.20	....	10.15	.44
Na_2O	undet.	.06	undet.	1.41	undet.
K_2O	undet.	2.63	undet.	2.36	undet.
H_2O at 100°	2.79	.23	1.92	.85	1.19
H_2O above 100°		.26		2.32	
TiO_2	....	....	....	.03	....
P_2O_5	....	....	....	.09	....
MnO	trace	....	....	.10	....
CO_2	....	....	....	6.29	....
	98.76	99.93	99.55	99.78	94.57
Insol. in HCl	88.68	....	91.87	....	95.54

F. Potsdam sandstone, Ablemans, Sauk County, Wisconsin. Described by Diller in Bull. 150, p. 80. Analysis by Schneider, record No. 1280. P. R. C. 15.

G. Banded sandstone, Peoa, Utah. Described by Diller in Bull. 150, p. 80. Analysis by Schneider, record No. 1280. P. R. C. 16.

H. Brown sandstone, Flagstaff, Arizona. Analysis by T. M. Chatard, record No. 1144.

I. Sandstone, Robinson mine, Summit County, Colorado. Analysis by L. G. Eakins, made in the Denver laboratory, partial.

	F.	G.	H.	I.
SiO_2	99.42	96.60	[a]79.19	56.33
Al_2O_3	.31	2.02	1.30	.77
Fe_2O_3			2.45	.97
MgO		.08	.23	7.30
CaO		.04	7.76	14.01
Na_2O				undet.
K_2O				undet.
H_2O at 100°	.18	.11	.32	undet.
H_2O above 100°		.29	2.94	undet.
CO_2			5.77	[b]19.04
	99.91	99.14	99.96	98.42

[a] Silica and insoluble matter.

[b] Calculated for bases.

CHERT.

From the lead-zinc region of southwestern Missouri and its extension into Kansas.

Collected by W. P. Jenney.

A. Unaltered chert, East Hollow, Belleville, Jasper County, Missouri.
B. Partly altered, same locality.
C. Altered to "cotton rock," same locality.
D. From the Surprise mine, Joplin, Missouri.

Analyses by E. A. Schneider, record No. 1205.

	A.	B.	C.	D.
SiO_2	98.17	98.92	98.71	99.46
Al_2O_3, Fe_2O_3	.83	.48	.43	.29
MgO	.01	.02	.02	trace
CaO	.05	.03	.03	.04
Ignition	.78	.42	.50	.34
	99.84	99.87	99.69	100.13

E. Blue chert, unaltered, Bonanza shaft, Galena, Kansas.
F. Same locality.
G. Altered, same locality.
H. Jasperite, Joplin, Missouri.
I. Jasperite, Galena, Kansas.

Analyses E, F, and G by E. A. Schneider, record No. 1205; H and I by L. G. Eakins, record No. 1208.

	E.	F.	G.	H.	I.
SiO_2	99.23	98.60	99.13	95.77	97.33
Al_2O_3, Fe_2O_3	.22	.52	.16	1.84	1.89
MgO	trace	trace	.01	.24	.09
CaO	.02	.10	trace	.54	.11
Ignition	.50	.40	.20	1.17	.77
	99.97	99.62	99.50	99.56	100.19

SILICEOUS SINTERS.

From the Yellowstone National Park and similar localities. Described by W. H. Weed in 9th Ann., p. 619. Analyses A to H, inclusive, by J. E. Whitfield, record Nos. 97, 100, 707, 708, 812, and 998; analysis I by E. A. Schneider, record No. 1254. A to E from Yellowstone National Park.

A. Dried siliceous jelly from Emerald Spring, Upper Basin.

B. Sinter from Solitary Spring, Upper Basin.

C. Grayish sinter from margin of Splendid Geyser.

D. Compact sinter from Old Faithful Geyser.

E. From Asta Spring, Hillside Group.

F, G, H. Three samples of sinter from Rotorua, New Zealand. For comparison with Yellowstone sinters.

I. Sinter from Mount Morgan gold mine, Queensland, Australia. Described by Weed in Am. Journ. Sci., 3d series, vol. 42, p. 165.

	A.	B.	C.	D.	E.
SiO_2	93.37	93.88	81.95	89.54	89.72
Al_2O_3	1.16	1.73	6.49	2.12	1.02
Fe_2O_3	trace	.14	trace	trace	
MgO	.05	.07	.15	trace	trace
CaO	.29	.25	.56	1.71	2.01
Na_2O	.11	.28	2.56	1.12	....
K_2O	.02	.23	.65	.30	....
H_2O (ign.)	4.17	3.37	7.50	5.13	7.34
NaCl	.08	.18	trace	trace	....
SO_3	.31	.20	.16	trace	trace
C, organic	.78	....	....	....	....
H, organic	.07	....	....	....	....
	100.41	100.33	100.02	99.92	100.09

	F.	G.	H.	I.
SiO_2	92.47	90.28	74.63	94.02
Al_2O_3	2.54	3.00	15.59	2.27
Fe_2O_3	....	....	....	
MgO	.15	trace	trace	trace
CaO	.79	.44	1.00	.07
Na_2O	....	....	.30	....
K_2O	....	....	1.02	....
H_2O at 105°	....	....	....	1.07
Ignition	3.99	6.24	7.43	2.29
	99.94	99.96	99.97	99.72

THE CARBONATE ROCKS: LIMESTONE, DOLOMITE, SIDERITE, ETC.

VERMONT AND MASSACHUSETTS.

A. White marble, Rutland, Vermont. Analysis by L. G. Eakins, record No. 1213.

B. The portion of A insoluble in dilute hydrochloric acid. Same analyst and number.

C. White marble, Lee, Massachusetts. Analysis by E. A. Schneider, record No. 1279. Described by Diller in Bull. 150, p. 299. P. R. C. 116.

D. Limestone, Lee, Massachusetts. Collected by B. K. Emerson. From cut on west side of railroad. Analysis by George Steiger, record No. 1654.

E. Dolomite, Charlemont, Massachusetts. Collected by Emerson. Analysis by Eakins, record No. 1343.

F. Dolomite, Webster, Massachusetts. Collected by Emerson. Analysis by H. N. Stokes, record No. 1634.

	A.	B.	C.	D.	E.	F.
Insoluble	8.00		.19			
SiO_2		56.69		.95	.67	1.01
Al_2O_3	.39	31.16	.24	.09	trace	.17
Fe_2O_3				none	.08	none
FeO	.14	2.13		.10	7.60	.37
MnO					1.61	.08
NiO					.03	
CaO	50.79	2.68	30.88	54.75	28.63	30.82
MgO	trace	3.27	21.42	.56	16.17	21.35
K_2O		undet.		.15		.10
Na_2O		undet.		.02		.01
H_2O	1.01			.08		.09
P_2O_5				.03		.06
CO_2	39.80		46.72	43.38	45.35	45.84
SO_3				.05		
	100.13	95.93	99.45	100.16	100.14	99.90

NEW YORK, PENNSYLVANIA, MARYLAND.

A. Dolomite-marble, New York Quarry Company, Tuckahoe, Westchester County, New York. Analysis by W. F. Hillebrand, record No. 746.

B. Hydraulic-cement rock, Akron, New York. Analysis by George Steiger, record No. 1655.

C. Compact gray limestone, Greason, Pennsylvania. Analysis by E. A. Schneider, record No. 1279.

D. Dolomite-marble, Cockeysville, Maryland. Analysis by Schneider, No. 1279. P. R. C. 117.

E. An earlier sample of D. Analysis by J. E. Whitfield, record No. 827. P. R. C. 117.

Rocks B, C, D, E are described by Diller in Bull. 150, pp. 127, 133, 300.

	A.	B.	C.	D.	E.
Insoluble	1.33		11.07	5.57	
SiO_2		9.03			.44
TiO_2		.16			
Al_2O_3		2.25		.40	1.22
Fe_2O_3	.21	.85			
FeO		.52			trace
CaO	30.68	26.84	39.26	29.08	30.73
MgO	20.71	18.37	9.00	20.30	20.87
K_2O		.85			
Na_2O		none			
H_2O	.16	.98	.18		1.22
P_2O_5		.03			
CO_2	46.66	40.33	38.82	44.26	45.85
Organic matter			.75		
	99.75	100.21	99.08	99.61	100.33

VIRGINIA AND WEST VIRGINIA.

A. Limestone, upper ledge, Moundsville Narrows, West Virginia.

B. Same as A, lower ledge. Analysis A and B by T. M. Chatard, record No. 127.

C. Trenton limestone, Lexington, Virginia. Analysis by R. B. Riggs, record No. 365.

D. Limestone, Staunton, Virginia. Analysis by George Steiger, record No. 1630.

E. Part of D insoluble in one-tenth hydrochloric acid.

F. Soluble part of D. Analyses E and F also by Steiger, same number. These three analyses are accompanied by analyses of the residual clay, formed by the weathering of the limestone. See section on clays.

	A.	B.	C.	D.	E.	F.
Insoluble	10.33	1.53				
SiO_2			.44	7.37	6.98	.39
TiO_2				.09	.09	none
Al_2O_3				1.92	1.39	.53
Fe_2O_3	.90	.96	.42	29	.25	.04
FeO				.63	none	.63
MnO	trace	trace		none	none	none
CaO	48.02	53.26	54.77	28.39	.04	28.35
MgO	1.08	.93	trace	18.30	.15	18.15
K_2O				1.09	.91	.18
Na_2O				.09	.04	.05
H_2O at 100°	.05	.10	1.08	.09	undet.	undet.
H_2O above 100°				.49	.15	.34
P_2O_5	trace	trace		.03	none	.03
CO_2	39.18	43.16	42.72	41.85	none	41.85
	99.56	99.94	99.43	100.63	10.00	90.54

GEORGIA.

A. Marble, Happy Valley.
B. "Creole" marble, Happy Valley.
C. Portion of B insoluble in dilute hydrochloric acid.
D. "Cherokee" marble, Happy Valley.
E. Portion of D insoluble in dilute hydrochloric acid.
Analyses by L. G. Eakins, record Nos. 464, 485.

	A.	B.	C.	D.	E.
Insoluble		1.84		2.01	
SiO_2	2.23		58.21		55.48
Al_2O_3	.91	.17	7.37	.15	15.58
Fe_2O_3	.22				
FeO		.05	.31	.06	trace
CaO	52.16	53.91	12.53	53.69	14.52
MgO	2.09	.83	20.42	.83	12.88
H_2O	.45	.13		.17	
CO_2	42.22	43.16		43.13	
	100.28	99.69	98.84	100.04	98.46

FLORIDA.

1. CORAL AND SHELL ROCKS, COLLECTED BY N. S. SHALER.

Partial analyses only. Chlorides and sulphates present; alkalies and phosphates not looked for.

A, B, C, D. Coquina gravel, Tortugas.
E. The same, Key West.
Analyses by F. W. Clarke, record No. 878.

	A.	B.	C.	D.	E.
SiO_2	.19	.22	.32	.21	.25
Al_2O_3, Fe_2O_3	.19	.47	.56	.76	.56
CaO	52.24	51.24	49.38	51.95	51.52
MgO	1.53	2.09	1.93	1.44	2.08
CO_2	41.46	41.07	40.39	41.53	41.58
H_2O	3.27	3.57	5.12	3.07	3.19
	98.88	98.66	97.70	98.96	99.18

F. Near Fort Worth.
G. East side of St. Johns River, near Seville.
H. Corroded surface, Miami Reef.
I. Near Oak Hill.
J. Near Melborne.

Analyses by F. W. Clarke, record No. 885.

	F.	G.	H.	I.	J.
SiO_2	2.94	8.50	2.99	5.87	17.83
Al_2O_3, Fe_2O_3	.23	.73	.65	.95	1.18
CaO	51.51	47.29	51.22	50.34	43.85
MgO	.71	1.51	.06	.37	.26
CO_2	41.59	39.00	41.22	39.62	34.31
H_2O	2.64	3.37	2.23	3.21	2.53
	99.62	100.40	98.37	100.36	99.96

K. Coarse shell mass, Senote.
L. Coral rock, Salt Key Bank.
M. Loggerhead Key.

Analyses by L. G. Eakins, record No. 882. The following analyses, also by Eakins, No. 883, are included for comparison:

N. Coralline bottom, Barbados.
O. Recent coral (Siderostria), Bermuda.

	K.	L.	M.	N.	O.
SiO_2	.22	.11	.20	1.17	.23
Al_2O_3	.18	.04	.22	.31	trace
Fe_2O_3					
CaO	54.87	53.54	53.54	46.45	55.16
MgO	.64	.71	.78	5.15	.20
CO_2	43.89	43.87	43.71	43.40	43.74
H_2O	.11	1.13	.81	2.73	.54
	99.91	99.40	99.26	99.21	99.87

2. MISCELLANEOUS ROCKS.

A to M inclusive. Thirteen borings from the artesian well at Key West. Partial analyses by Steiger, record No. 1553. The figures at tops of columns give depths in feet from which samples were taken.

	A.	B.	C.	D.	E.	F.
	25	100	150	350	600	775
SiO_2	.17	.25	.12	3.52	5.10	.13
Al_2O_3	.20	.17	.08	.40	.35	.14
Fe_2O_3	.07	.07				
CaO	54.03	54.01	54.38	51.46	48.87	46.53
MgO	.29	.77	.86	1.67	2.50	6.70
CO_2	42.52	42.84	43.36	41.77	40.72	43.60
	97.28	98.11	98.80	98.82	97.54	97.10

	G.	H.	I.	J.	K.	L.	M.
	1125	1325	1400	1475	1625	1850	2000
SiO_2	.05	.07	.19	.06	.05	.03	.07
Al_2O_3, Fe_2O_3	.21	.11	.16	.14	.17	.17	.16
CaO	53.84	54.49	55.12	54.48	53.90	54.28	54.02
MgO	.86	.62	.30	.73	1.14	1.12	1.06
CO_2	42.87	43.29	43.28	43.38	43.37	43.13	43.20
	97.83	98.58	99.05	98.79	98.63	98.73	98.51

P_2O_5 is present. Is included with Al_2O_3 and Fe_2O_3.

N. Supposed cement rock, River Junction. Received from D. T. Day. Analysis by George Steiger; record No. 1844.

SiO_2	12.31
Al_2O_3	12.19
Fe_2O_3	.66
CaO	26.28
MgO	16.72
K_2O	none
Na_2O	.50
H_2O at 100°	.94
H_2O above 100°	2.05
P_2O_5	.05
CO_2	38.12
	99.82

TENNESSEE, ALABAMA, LOUISIANA.

A. Limestone, Knoxville, Tennessee. Analysis by L. G. Eakins, record No. 1159.

B. Knox dolomite, Morrisville, Alabama. Described by Russell in Bull. 52, together with a residual clay derived from it. See section on clays. Analysis by W. F. Hillebrand, record No. 797.

C. Limestone from Rayborn's salt-lick, Bienville Parish, Louisiana. Analysis by R. B. Riggs, record No. 323.

D. White marble, streaked with black. From 5 miles west of Winnfield, Louisiana. Analysis by W. F. Hillebrand, record No. 760. In addition to the constituents named in the table, this marble contains traces of barium, strontium, chlorine, and organic matter.

	A.	B.	C.	D.
Insoluble				.65
SiO_2	.17	3.24	.55	
Al_2O_3	.04	.17	1.61	trace
Fe_2O_3	.23	.17		
FeO		.06		trace
MnO			trace	.10
CaO	55.47	29.58	54.09	55.01
MgO	.30	20.84	.06	.60
H_2O	.21	.30		.13
P_2O_5			.05	
CO_2	43.63	45.54	44.12	43.43
SO_3			.05	.27
	100.05	99.90	100.53	100.19

TEXAS.

Supposed cement rock, Uvalde quadrangle. Collected by T. Wayland Vaughan. Analysis by W. F. Hillebrand, record No. 1759.

A, the rock; B, the part insoluble in dilute nitric acid.

	A.		B.
SiO_2	.10	SiO_2	20.80
Fe_2O_3, Al_2O_3	.09	Al_2O_3 Fe_2O_3 P_2O_5	3.44
CaO	40.82		
MgO	.18		
CO_2	32.41	H_2O	1.14
Insoluble	25.57	Alkalies	.19
NaCl, Mn, H_2O *a*	.83		25.57
	100.00		

a By difference.

OHIO.

A, B, C, D. Trenton limestone from New Vienna.

Partial analyses by F. W. Clarke and R. B. Riggs, record Nos. 729, 730, 732. Iron and alumina are present in soluble form.

	A.	B.	C.	D.
Insoluble	8.47	9.93	2.12	28.43
CaO	47.16	49.04	51.18	23.00
MgO	1.52	.58	3.08	12.90
CO_2	36.20	37.64	42.04	30.82
	92.35	97.19	98.42	95.15

E. Trenton limestone, Arcadia, Hancock County.

F. Air-line Junction, Toledo. This sample contains a great deal of ferrous carbonate.

G. Gas rock, St. Henry's well, Mercer County.

H. Oil rock, Lima.

All Trenton. Analyses, partial, by Clarke and Riggs, record Nos. 729, 730.

	E.	F.	G.	H.
Insoluble	8.56	3.52	2.27	1.64
CaO	47.17	30.64	50.34	32.24
MgO	2.59	18.05	2.86	17.36
CO_2	38.54	42.82	40.96	43.92
	96.86	95.03	96.43	95.16

The following partial analyses by F. W. Clarke, record No. 738, all relate to Trenton limestones:

A. Well No. 3, Bryan. Gas rock.
B. McElree well, Kenton. Depth, 1,315 feet.
C. Huntsville. Depth, 1,405 feet.
D. Prospect. Depth, 1,650 feet.
E. Findlay street well, Dayton. Depth, 975 feet.
F. Xenia. Depth, 1,075 feet.
G. New Madison. Depth, 1,150 feet.

	A.	B.	C.	D.
Insoluble	9.22	5.26	4.41	26.12
Fe_2O_3, Al_2O_3	1.51	1.10	3.15	2.57
$CaCO_3$	49.00	84.32	57.23	66.02
$MgCO_3$	38.59	8.43	33.16	3.77
	98.32	99.11	98.95	98.58

	E.	F.	G.
Insoluble	12.34	9.23	11.11
Fe_2O_3, Al_2O_3	.58	.18	3.60
$CaCO_3$	82.36	86.54	64.91
$MgCO_3$	1.67	2.99	17.98
	96.95	98.94	97.60

In C and G there is ferrous carbonate.

Partial analyses by Charles Catlett, record Nos. 754, 755, 756, 757; all of Trenton limestones from the natural-gas belt.

A. London. Depth, 1,594 feet.
B. Air-line Junction, Toledo. Depth, 1,415 feet.
C. Celina. Depth, 1,112 feet.
D. City well No. 2, Upper Sandusky.
E. Sandusky. Depth, 2,260 feet.
F. Gas rock. Pauck well, St. Marys Township, Auglaize County.
G. Gas rock. Bennett well, St. Marys Township. Depth, 1,121 feet.
H. First city well, Carey. Depth, about 1,350 feet.
I. Well No. 2, Fort Recovery. Depth, 1,065 feet.
J. Waggoner well, 6 miles west of Fremont. Gas rock.
K. Loomis and Nyman well, Tiffin. Depth, 1,470 to 1,481 feet.
L. Loomis and Nyman well, Tiffin. Depth, 1,488 to 1,494 feet.
M. Port Clinton. Depth, 1,660 to 1,700 feet.
N. Wauseon. Depth, 2,135 feet.
O. Napoleon. Depth, 1,830 feet.
P. Kossuth, Allen County. Oil rock.
Q. Doenze's well, Franklin Township, Mercer County. Depth, 1,107 feet.

	A.	B.	C.	D.	E.	F.
Insoluble	15.90	2.88	2.95	8.18	3.65	3.18
Al_2O_3, Fe_2O_3	1.84	8.68	2.95	4.31	4.58	3.12
$CaCO_3$	77.69	54.68	68.41	64.25	54.62	52.18
$MgCO_3$	1.89	25.73	24.18	15.93	33.67	38.42
	97.32	91.97	98.49	92.67	96.52	96.90

	G.	H.	I.	J.	K.	L.
Insoluble	1.66	5.72	1.89	5.22	5.66	9.88
Al_2O_3, Fe_2O_3	2.48	3.08	1.57	6.32	4.86	1.46
$CaCO_3$	56.94	80.11	87.88	52.93	52.89	79.39
$MgCO_3$	35.55	8.09	7.43	32.75	33.46	6.20
	96.63	97.00	98.77	97.22	96.87	96.93

	M.	N.	O.	P.	Q.
Insoluble	7.46	18.24	2.66	1.08	3.68
Al_2O_3, Fe_2O_3	4.16	7.28	2.14	.66	8.38
$CaCO_3$	71.96	42.82	53.85	90.72	69.53
$MgCO_3$	14.34	28.11	37.33	6.69	10.98
	97.92	96.45	95.98	99.15	92.27

INDIANA.

A. Buff limestone, Hoosier Stone Company, Bedford.
B. Blue limestone, same locality.
Analyses by F. W. Clarke, record Nos. 306, 307.

	A.	B.
SiO_2	.63	1.69
Fe_2O_3	.39	.49
CaO	54.19	54.18
MgO	.39	.37
P_2O_5	trace	trace
CO_2	44.01	43.08
SO_3	none	none
	99.61	99.81

The following Trenton limestones are all from the natural-gas belt:
C. Union City. Depth, 1,160 feet.
D. Bluffton. Depth, 1,062 to 1,067 feet.
E. Muncie. Depth, 920 feet.
F. Greensburg. Depth, 867 feet.
G. Vernon. Depth, 905 feet.
H. Wabash. Depth, about 900 feet.
Analysis C by F. W. Clarke, record No. 738. The remainder by Charles Catlett, Nos. 753, 758.

	C.	D.	E.	F.	G.	H.
Insoluble	2.14	2.37	3.30	.87	8.00	3.52
$Al_2O_3.Fe_2O_3$	1.23	4.48	3.72	.55	.60	7.58
$CaCO_3$	83.21	53.43	51.96	94.60	85.56	53.18
$MgCO_3$	12.48	37.47	38.11	.36	trace	30.53
	99.06	97.75	97.09	96.38	94.16	94.81

MISSOURI.

Limestones and dolomites collected by W. P. Jenney. Analyses by L. G. Eakins, record Nos. 1184, 1207. CO_2 calculated.

A, B. Cherokee limestone, quarry near Seneca, Newton County.
C, D. The same, near Grand Falls, Newton County.
E, F. Dolomite, Oswego land, Joplin.

	A.	B.	C.	D.	E.	F.
Insoluble	.66	1.21	1.01	1.01	29.77	11.66
Al_2O_3	.11	.13	.08	.13	1.32	1.03
FeO	.05	.07	.05	trace		
MnO	trace	trace	.03	trace	....	....
CaO	55.29	54.92	54.98	55.11	21.46	28.72
MgO	.23	.20	.31	.32	14.79	17.26
CO_2	43.69	43.31	43.54	43.65	33.13	41.55
	100.03	99.84	100.00	100.22	100.47	100.22

KANSAS.

A. Limestone, Silverdale. Analysis by Charles Catlett, record No. 967.

B. Cherokee limestone, Short Creek, near Spring River, Cherokee County. Analysis by L. G. Eakins, record No. 1184.

C. Supposed marl, large surface deposit near Wakeeney, Trego County. Analysis by F. W. Clarke, record No. 212.

	A.	B.	C.
Insoluble	....	.32	....
SiO_2	5.27	....	14.06
Al_2O_3	1.07	.17	....
Fe_2O_3	.71	....	5.10
FeO	.32	.20	....
MnO	....	.02	....
CaO	50.36	55.25	43.05
MgO	.56	.35	.50
K_2O	.10	....	....
Na_2O	.20	....	....
H_2O	.78	....	1.77
P_2O_5	.06	....	....
CO_2	40.34	43.79	35.03
SO_2	.07	....	....
	99.84	100.10	99.51

MICHIGAN, WISCONSIN, MINNESOTA, CANADA.

Most of the rocks considered under this heading were described by Irving and Van Hise in Mon. XIX, pages 131 and 191. A few other analyses, also representing Van Hise's collections, are taken from the laboratory records. The Canadian rocks are from near the boundary line, and relate directly to others gathered upon the Minnesota side.

A. Dolomite, near Sunday Lake, Gogebic district, Michigan. Analysis by W. F. Hillebrand, record No. 767.

B. Dolomite, Penokee region, Wisconsin, NW. ¼ sec. 22, T. 44 N., R. 5 W. Analysis by Hillebrand, record No. 768.

C. Limestone, bed of Slate Creek, Huron Bay slate quarries, Michigan. Analysis by T. M. Chatard, record No. 894. From laboratory records; not in the monograph cited.

D. Limestone, east end of Ogiskemannissi Lake, Minnesota. Analysis by Chatard, record No. 899. Not in monograph.

	A.	B.	C.	D.
SiO_2	3.07	.63	7.05	41.99
Al_2O_3	....	....	.48	1.24
Fe_2O_3	.09	.03	1.33	.42
FeO	.86	.75	undet.	4.77
MnO	.15	.08	.19	.26
CaO	29.72	30.94	50.08	16.85
MgO	19.95	20.68	.57	8.41
H_2O at 105°	.30	.27	....	.05
H_2O ign			.25	1.02
P_2O_5	....	....	.27	.05
CO_2	45.31	46.27	39.68	24.70
SO_3	....	....	.21	.32
Cl	trace	trace	....	....
	99.45	99.65	100.11	100.08

E. Iron carbonate, SE. ¼ sec. 20, T. 47 N., R. 43 W., Michigan.

F. Iron carbonate, south side of Sunday Lake, Michigan.

G. Iron carbonate, Palms mine, Gogebic district, Michigan.

Analyses E, F, and G by W. F. Hillebrand, record Nos. 769, 770, 771.

H. Iron carbonate, Miner and Wells Option, sec. 13, T. 47 N., R. 46 W., Michigan. Analysis by T. M. Chatard, record No. 893.

I. Iron carbonate, NW. ¼ sec. 18, T. 47 N., R. 45 W., Michigan. Analysis by Chatard, No. 895.

	E.	F.	G.	H.	I.
SiO_2	3.16	28.86	46.47	46.01	36.73
TiO_2	....	.20	.10	.12	.19
Al_2O_3	.08	1.29	.70	.83	.38
Fe_2O_3	.93	1.01	.86	1.35	.98
FeO	15.18	37.37	28.57	26.07	34.81
MnO	1.15	.97	.40	2.09	.52
CaO	26.65	.74	.49	.63	.48
MgO	11.01	3.64	2.30	2.86	2.74
H_2O at 105°	.54	.68	.60	1.71	.12
H_2O ign					1.40
P_2O_5	.06	trace	trace	.07	.01
CO_2	41.10	25.21	19.24	17.72	22.44
SO_3	....	....	....	.15	.16
Cl	trace	....	?	....	....
FeS_2	.34	....	....	....	....
	100.20	99.97	99.73	99.61	100.96

J. Iron carbonate, Penokee iron range, NE. ¼ sec. 6, T. 45, R. 2 E., Wisconsin. P. R. C. 999.

K, L. Black, slaty, carbonaceous iron carbonates, Animikie formation, Kakabikka Falls, Kaministiquia River, Canada.

M. Iron carbonate, west end of Gunflint Lake, Minnesota.

N. Iron carbonate, north side of Gunflint Lake, Minnesota.

O. Iron carbonate, north side of Gunflint Lake, Canada.

Analyses J, K, and L by R. B. Riggs, record Nos. 376, 377, 378; M, N, and O by T. M. Chatard, record Nos. 897, 898, 900.

	J.	K.	L.	M.	N.	O.
SiO_2	15.62	37.73	54.26	58.23	46.46	23.90
TiO_2				trace ?	trace ?	none
Al_2O_3	4.27	3.41	2.57	.06	.24	.07
Fe_2O_3	8.14	6.42	3.62	5.01	.64	.44
FeO	32.85	22.92	19.63	18.48	26.34	10.72
MnO	5.06	.40	.19	.25	.21	.28
CaO	.81	1.26	1.07	.38	1.87	22.25
MgO	2.66	3.98	2.93	9.59	3.10	8.52
H_2O at 110°	.68	2.74	1.20	.07	.07	none
H_2O at redness				2.01	1.15	.99
P_2O_5				.03	.13	trace
CO_2	30.32	18.01	14.93	5.22	19.96	32.42
SO_3				.19	.14	.17
C		3.54	.45			
	100.41	100.41	100.85	99.52	100.31	99.76

P. Ferrodolomite, Marquette district, Michigan. Analysis by George Steiger, record No. 1473. P. R. C. 994.

Q. Ferrodolomite, Marquette district, Michigan.

R. Portion of Q insoluble in hydrochloric acid.

S. Soluble portion of Q.

Analyses Q, R, and S by George Steiger, record No. 1442. These rocks are not in the monograph cited.

	P.	Q.	R.	S.
SiO_2	42.37	26.97	26.67	.30
Al_2O_3		1.30	.12	1.18
Fe_2O_3	1.09	2.31	.16	2.15
FeO	31.41	39.77		39.77
MnO		.29		.29
CaO	.50	.66		.66
MgO	2.48	1.94	.10	1.84
Alkalies		.09		.09
H_2O at 100°		.10		
H_2O above 100°		.51		
P_2O_5		.03		.03
CO_2	21.80	26.20		26.20
	99.65	100.17	27.05	72.51

YELLOWSTONE NATIONAL PARK.

Travertines described by W. H. Weed in 9th Ann., p. 619.

A. Terrace below the hotel.
B. Cupids Cave.
C. Near Sulphur Spring No. 246, Mammoth Hot Springs.
D. Extinct spring, main terrace, Mammoth Hot Springs.
E. Ridge behind main terrace.

Analysis C by F. A. Gooch, record No. 243; A, B, D, and E b J. E. Whitfield, record Nos. 240, 242, 244, 245.

	A.	B.	C.	D.	E.
SiO_2	.08	.15	.01	.06	.26
Al_2O_3	.15	.49	.05	.14	.11
Fe_2O_3					
CaO	53.83	53.41	55.02	55.02	54.06
MgO	.90	.42	.07	.06	.66
K_2O		.01	.04		
Na_2O		.03			
H_2O	1.43	2.44	1.61	1.06	1.19
NaCl	.02	.13	.12	.20	.26
KCl				.08	
SO_3	1.72	.55	.49	.70	1.34
CO_2	41.79	41.96	42.25	42.25	42.14
C (organic)	.21	.37	.11	.24	none
	100.13	99.96	99.77	99.81	100.02

MONTANA.

Rocks collected by A. C. Peale. Analyses by Charles Catlett, record Nos. 890, 905.

A. North of East Gallatin River.
B. West of North Boulder River.
C, D. North of East Gallatin River.
E. Base of Carboniferous, west side of Bridger Range.
F. Middle Carboniferous, north of Gallatin River.
G, H. Upper Carboniferous, north of Gallatin River.

Analyses all partial. A, B, C, D, and H were published by Peale in Bull. 110, pp. 16, 28, and 40.

	A.	B.	C.	D.
Insoluble	.34	1.78	23.50	35.26
$Fe_2O_3Al_2O_3$	.22	.40	2.50	1.92
$CaCO_3$	54.54	54.54	67.85	59.11
$MgCO_3$	43.63	42.62	6.18	1.96
	99.73	99.34	100.03	98.25

	E.	F.	G.	H.
Insoluble	9.98	5.99	50.74	25.24
Fe_2O_3, Al_2O_3	.38	.58	.30	5.30
$CaCO_3$	88.50	91.96	32.28	40.21
$MgCO_3$	.95	1.35	13.91	25.25
	99.81	99.88	97.23	96.00

COLORADO.

1. DENVER BASIN.

Rocks described by Emmons in Mon. XXVII. Analyses made b L. G. Eakins, in the Denver laboratory.

A. Upper Wyoming limestone, Morrison.

B. Niobrara dolomite.

	A.	B.
Insoluble	5.32	12.01
Al_2O_3	.53	.54
Fe_2O_3	.38	.11
MnO	.49	.20
CaO	48.73	27.49
MgO	2.95	18.03
H_2O	.11	.61
P_2O_5	.03	.03
CO_2	41.71	41.40
	100.25	100.42

2. LEADVILLE DISTRICT.

Rocks described by Emmons in Mon. XII. Analyses A and E by W. F. Hillebrand; B, C, and D by A. Guyard; all made in the Denver laboratory.

A. Upper blue limestone, Silver Wave mine.
B. Upper blue limestone, Dugan quarry.
C. Upper blue limestone, Glass-Pendery mine.
D. Montgomery quarry, near base of blue limestone.
E. White limestone, upper part, Carbonate Hill quarry.

	A.	B.	C.	D.	E.
SiO_2	.21	.70	.27	7.76	11.84
Al_2O_3	.27	.17	.04	.11	1.66
Fe_2O_3	.21	.11	.22	.10	1.51
FeO	.24	.38	.13	.57	.83
MnO	trace	.05	.20	.06	....
CaO	30.79	30.43	29.97	27.26	26.60
MgO	21.14	20.78	21.52	20.05	17.41
K_2O	.03	.05	.01	.02	.02
Na_2O	.06	.09	.02	.04	.03
H_2O	.22	.04	.07	.05	.48
P_2O_5	trace	.12	.03	.07	trace
CO_2	46.84	46.93	47.39	43.79	40.01
SO_3	trace	....	....	trace	....
Cl	.10	.14	.04	.06	.05
FeS_2	trace	trace	....	trace	....
Organic matter	.03	.03	.02	.07	....
	100.14	100.02	99.93	100.01	100.44

3. FAIRPLAY, PARK COUNTY.

Analyses made by W. F. Hillebrand, in the Denver laboratory.

A. Serpentinous limestone, Buckskin Gulch.
B. Limestone, Fairplay.
C. Limestone, Mount Silverheels.
D. Dolomite-limestone, Mount Silverheels.

Analyses B, C, and D partial, with CO_2 calculated to satisfy bases.

	A.	B.	C.	D.
Insoluble	....	2.37	.51	1.98
SiO_2	17.64	....	....	....
Al_2O_3	.99	....	....	....
Fe_2O_3	.62	....	....	....
FeO	.18	.19	.10	.46
MnO	trace			
CaO	32.23	53.64	55.50	30.19
MgO	19.01	.73	.17	20.47
Alkalies	.07	....	....	....
H_2O	3.72	.51	....	....
P_2O_5	.05	....	....	....
CO_2	25.33	42.93	43.82	46.52
Cl	.08	....	....	....
	99.92	100.37	100.10	99.62

4. PITKIN COUNTY.

Limestones and dolomites collected under the direction of S. F. Emmons. Analyses by George Steiger, record No. 1559. CO_2 calculated to satisfy bases. Analyses partial only.

	A.	B.	C.	D.	E.	F.	G.
Insoluble	.16	.80	1.02	13.63	1.42	31.12	7.78
Fe_2O_3	.22	1.63	2.10	1.88	3.34	.36	.88
FeO	.09	.23	.06	.64	.42	.19	.22
CaO	30.66	31.19	33.74	35.98	31.61	37.28	38.85
MgO	20.94	19.69	16.76	8.25	18.06	.54	9.97
CO_2	47.13	46.16	44.94	37.35	44.70	29.88	41.47
	99.20	99.70	98.62	97.73	99.55	99.37	99.17

The following samples from Aspen were analyzed by L. G. Eakins in the Denver laboratory. Partial analyses, CO_2 calculated as before.

H. Blue limestone.
I. Limestone.
J. Dolomite.

	H.	I.	J.
Insoluble	.52	.33	.84
Fe_2O_3	.88	trace	1.31
CaO	31.16	55.81	30.46
MgO	20.64	.16	20.90
CO_2	47.19	44.03	46.92
	100.39	100.33	100.43

5. GLENWOOD SPRINGS, GARFIELD COUNTY.

Limestones and dolomites collected under the direction of S. F. Emmons. Analyses, partial only, by George Steiger, record No. 1559. CO_2 calculated to satisfy bases.

	A.	B.	C.	D.	E.	F.	G.
Insoluble	21.45	47.74	6.47	3.71	9.44	17.82	1.96
Fe_2O_3	.97	.18	.42	none	.26	.74	.03
FeO	.23	.71	.35	.55	.32	.57	.35
CaO	40.64	15.87	46.65	47.40	39.56	26.50	32.14
MgO	.73	10.60	2.64	4.49	8.56	14.86	18.72
CO_2	32.73	24.13	39.55	42.15	40.52	37.18	45.85
	96.75	99.23	96.08	98.30	98.66	97.67	99.05

	H.	I.	J.	K.	L.	M.
Insoluble	2.27	.22	.23	.06	.22	.11
Fe_2O_3	.14	trace	.09	none	.10	.03
FeO				none	.10	.07
CaO	53.79	55.17	55.49	55.81	55.45	55.68
MgO	.46	.21	.24	trace	.24	trace
CO_2	42.76	43.58	43.87	43.85	43.84	43.75
	99.42	99.18	99.92	99.72	99.95	99.64

6. TENMILE DISTRICT, SUMMIT COUNTY.

Partial analyses, made in the Denver laboratory, by W. F. Hillebran CO_2 calculated to satisfy bases. Manganese and iron present as ca bonates, but Fe_2O_3 and Al_2O_3 were not separated from them.

A. A. V. Fletcher shaft, Copper Mountain.
B. Pittston tunnel.
C. Middle Carboniferous, Pearl Hill.
D. Summit quarry.
E. Dolomite, Sheep Mountain.
F. Oolitic limestone, northwest corner of area.
G. Pittston tunnel.

	A.	B.	C.	D.	E.	F.	G.
Insoluble...	2.69	.62	10.09	1.75	.78	1.37	7.91
FeO, MnO..	.21	.25	1.19	.32	1.50	.20	.32
CaO........	54.23	55.24	28.01	53.60	30.55	55.17	50.83
MgO.......	.21	.24	18.33	1.23	20.15	.28	.70
CO_2........	42.97	43.81	42.63	43.65	47.04	43.76	40.90
	100.31	100.16	100.25	100.55	100.02	100.78	100.66

H. Dolomite, Blackbird tunnel, Tucker Mountain.
I. Summit King shaft, Summit City.
J. Middle Carboniferous dolomite, Ptarmigan Hill.
K. Hill north of Sugar Loaf.
L. Quarry on southeast side of Searls Gulch.
M. Open cut below Sabbath Rest tunnel, Elk Mountain.
N. Triassic, Jacque Mountain.

	H.	I.	J.	K.	L.	M.	N.
Insoluble...	2.68	6.75	.65	4.42	.36	.82	2.04
FeO, MnO..	1.52	3.08	1.67	.10	.17	.07	.15
CaO........	31.60	28.05	30.90	52.97	55.58	55.47	54.62
MgO.......	18.27	18.15	19.75	.40	.37	.22	.25
CO_2........	45.75	43.88	47.02	42.12	44.17	43.86	43.28
	99.82	99.91	99.99	100.01	100.65	100.44	100.34

UTAH.

A. Marble from the Ontario mine, east end of the 1,000-foot level. Analysis made by L. G. Eakins, in the Denver laboratory.

B. Oolitic sand from shore of Great Salt Lake. Analysis by T. M. Chatard, record No. 156.

	A.	B.
Insoluble in HCl	9.61	4.03
Al_2O_3	trace	.20
Fe_2O_3		
CaO	50.63	51.33
MgO	.09	.72
Alkalies		.63
CO_2	[a] 39.89	41.07
P_2O_5		trace
SO_3		.89
H_2O		.83
Organic matter		.27
	100.22	99.97

[a] Calculated to satisfy bases.

NEVADA AND CALIFORNIA.

A. Crystalline limestone, Eureka, Nevada. Analysis by E. A. Schneider, record No. 1279.

B. From base of the Hamburg limestone, Eureka district, Nevada.

C. From summit of Hamburg limestone, Eureka.

D. Pogonip limestone (Silurian), Eureka district. Analyses B, C, and D made by W. F. Hillebrand in the Denver laboratory. Described by Hague in Mon. XX, pp. 40, 49. In D the CO_2 was taken by difference.

E. Cretaceous limestone from Mount Diablo, California. Analysis made by W. H. Melville in the San Francisco laboratory and published in Bull. Geol. Soc. Amer., vol. 2, p. 409. FeO and alkalies undetermined.

F. White deposit, White Terrace, west shore of Pyramid Lake, Nevada. Analysis by T. M. Chatard, record No. 34.

	A.	B.	C.	D.	E.	F.
Insoluble	.53					
SiO_2		24.00	3.94	9.34	21.19	22.00
Al_2O_3		.12	.64	.31	.39	5.14
Fe_2O_3		.12	.43	.29	1.52	2.04
FeO			.20			
MnO			.61		3.61	
CaO	30.60	41.97	51.96	50.01	35.61	37.22
MgO	21.69	.80	.52	.54	1.39	1.89
Alkalies		traces	traces	traces		
H_2O at 100°		.16	.37	.13	.76	3.32
H_2O above 100°					2.33	
P_2O_5		.07	.50	.24	2.55	
CO_2	47.13	32.62	40.71	39.11	26.84	28.53
Organic matter		traces	.03	traces		
Cl		.01	.01	.03		
	99.95	99.87	99.92	100.00	96.19	100.14

HAWAIIAN ISLANDS.

Coral and shell rocks, analyzed for N. S. Shaler by L. G. Eakins, record Nos. 886, 887, 889. Analyses only partial.

A. Laie.
B, C. Kohuku Bluff.
D. Kohuku coral flat.
E. Point near coral flat.
F. "Modern chalk," Oahu.
G. Diamond Head.
H. Under lava, Honolulu.
I. Old reef, Waialua.
J. Campbell's ranch, Waianea, Oahu.
K. Wailuku Bay.
L. Reef No. 3, Honolulu.
M. Prison Knoll, Honolulu.

	A.	B.	C.	D.	E.	F.	G.
SiO_2	.35	.19	.67	.25	.26	33.25	2.97
Al_2O_3	.19	.52	.73	.49	.21	19.53	2.88
Fe_2O_3						10.71	
CaO	49.38	49.34	51.09	53.34	52.17	11.37	44.82
MgO	1.74	4.60	2.50	.67	1.51	3.06	5.32
CO_2	41.89	44.33	43.64	43.89	43.95	11.09	40.81
H_2O	4.74	.40	.79	.93	.70	9.84	1.86
	98.29	99.38	99.42	99.57	98.80	98.85	98.66

	H.	I.	J.	K.	L.	M.
SiO_2	5.34	1.05	.53	.45	3.53	.81
Al_2O_3	5.11	1.26	.62	1.82	2.26	1.19
Fe_2O_3						
CaO	42.24	51.07	50.69	50.54	46.52	52.67
MgO	5.95	.11	2.98	1.83	2.45	.42
CO_2	38.71	42.68	43.96	42.80	40.59	42.81
H_2O	1.61	1.33	.46	1.93	2.75	1.24
	98.96	97.50	99.24	99.37	98.10	99.14

SLATES AND SHALES.

VERMONT.

Samples A to I, inclusive, are described by T. Nelson Dale in 19th Ann., Part III. Analyses by W. F. Hillebrand, record Nos. 1567, 1656. Roofing slates of Cambrian age.

A. McCarty quarry, South Poultney.
B. Unfading green, Eureka quarry, Poultney.
C. Sea green, Griffith and Nathaniel quarry, South Poultney.
D. Sea green, Rising and Nelson's quarry, Pawlet.
E. Sea green, Brownell quarry, Pawlet.
F. Black, American Black Slate Company, Benson.

	A.	B.	C.	D.	E.	F.
SiO_2	61.63	59.27	62.37	67.76	59.84	59.70
Al_2O_3	16.33	18.81	15.43	14.12	15.02	16.98
Fe_2O_3	4.10	1.12	1.34	.81	1.23	.52
FeO	2.71	6.58	5.34	4.71	4.73	4.88
MgO	2.92	2.21	3.14	2.38	3.41	3.23
CaO	.50	.42	.77	.63	2.20	1.27
Na_2O	1.26	1.88	1.14	1.39	1.12	1.35
K_2O	5.54	3.75	4.20	3.52	4.48	3.77
H_2O at 100°	.31	.32	.34	.23	.41	.30
H_2O above 100°	3.24	3.98	3.71	2.98	3.44	3.82
TiO_2	.68	.99	.74	.71	.74	.79
P_2O_5	.16	.11	.06	.07	.09	.16
MnO	.09	.13	.22	.10	.34	.16
BaO	.06	.05	.07	.04	.09	.08
CO_2	.41	.21	.87	.40	2.98	1.40
FeS_2	.04	.15	.06	.22	.05	1.18
C	none	none	trace	none	trace?	.46
	99.98	99.98	99.80	100.07	100.17	100.05

All six contain traces of lithia, of sulphates, and of nickel or cobalt.

G. Unfading green, Valley Slate Company's quarry, Poultney.
H. Mottled, purple and green, Eureka quarry, Poultney.
I. Purple, 1 mile south of Hydeville, in Castleton.

	G.	H.	I.
SiO_2	59.48	60.24	60.96
Al_2O_3	18.22	18.46	16.15
Fe_2O_3	1.24	2.56	5.16
FeO	6.81	5.18	2.54
MgO	2.50	2.33	3.06
CaO	.56	.33	.71
Na_2O	1.55	1.57	1.50
K_2O	3.81	4.09	5.01
H_2O at 110°	.17	.18	.17
H_2O above 110°	4.05	3.81	3.08
TiO_2	1.02	.92	.86
P_2O_5	.10	.11	.23
MnO	.07	.07	.07
BaO	.05	.03	.04
CO_2	.39	.08	.68
FeS_2	.13	.16	none
F	.08	undet.	undet.
N, as NH_3	.03	.03	.01
	100.26	100.15	100.23

All three contain traces of lithia, nickel, and chlorine, and possibly of zirconia; in G and H traces of strontia, but none in I.

J. Slate from Guilford, collected for the Educational Series of Rock Specimens. Analysis by L. G. Eakins, record No. 1316.

K. Slate from the Lakeshore quarry, Hydeville. Analysis by Eakins, record No. 1159.

	J.	K.
SiO_2	60.72	58.15
Al_2O_3	22.59	18.93
Fe_2O_3	....	2.91
FeO	6.03	5.64
MgO	2.05	2.70
CaO	.41	.60
Na_2O	.86	1.17
K_2O	3.69	3.92
H_2O	3.01	4.56
TiO_2	....	.93
P_2O_5	.13	.12
MnO	trace	.07
SO_3	....	.16
C	.57	....
	100.06	99.86

NEW YORK.

Roofing slates from Washington County, collected by T. Nelson Dale. Of Cambrian age. Described by Dale in 19th Ann., Part III.

A. Red, three-fourths mile south of Hampton Village.

B. Empire Red Slate Company, near Granville.

C. National Red Slate Company, Granville.

D. Green, three-fourths mile northwest of Janesville.

Analyses by W. F. Hillebrand, record No. 1567.

	A.	B.	C.	D.
SiO_2	67.61	67.55	56.49	67.89
Al_2O_3	13.20	12.59	11.59	11.03
Fe_2O_3	5.36	5.61	3.48	1.47
FeO	1.20	1.24	1.42	3.81
MgO	3.20	3.27	6.43	4.57
CaO	.11	.26	5.11	1.43
Na_2O	.67	.61	.52	.77
K_2O	4.45	4.13	3.77	2.82
H_2O at 110°	.45	.40	.37	.36
H_2O above 110°	2.97	3.03	2.82	3.21
TiO_2	.56	.58	.48	.49
P_2O_5	.05	.10	.09	.10
MnO	.10	.19	.30	.16
BaO	.04	.31	.06	.04
CO_2	none	.11	1.42	1.89
FeS_2	.03	.04	.03	.04
	100.00	100.02	100.38	100.08

All contain traces of lithia, of sulphates, and of nickel or cobalt. No carbonaceous matter is present.

E. Red slate, from quarry 3 miles north of Raceville.
F. Green spot in E.
G. Purple rim of green spot F.
Analyses by W. F. Hillebrand, record No. 1656.

	E.	F.	G.
SiO_2	63.88	65.44	64.59
Al_2O_3	9.77	9.38	10.23
Fe_2O_3	3.86	1.09	1.79
FeO	1.44	1.06	1.19
MgO	5.37	4.92	5.12
CaO	3.53	4.53	4.07
Na_2O	.20	.22	.23
K_2O	3.45	3.57	3.70
H_2O at 110°	.27	.25	.28
H_2O above 110°	2.48	2.10	2.29
TiO_2	.47	.52	.51
P_2O_5	.08	.08	.08
MnO	.21	.32	.26
BaO	.05	.06	.05
CO_2	5.08	6.55	5.84
FeS_2	trace	.04	trace
	100.14	100.13	100.23

Contain traces of lithia and nickel. Fluorine not determined.

KENTUCKY, GEORGIA, ALABAMA.

A. Indurated Carboniferous shale, in contact with the peridotite dike of Elliott County, Kentucky. Described by Diller in Bull. 38. Analysis by T. M. Chatard, record No. 351.

B. Fragment of shale included in the Elliott County dike. Analysis by Chatard, record No. 353.

C. Bituminous shale, Dry Gap, Georgia. Analysis by L. G. Eakins, record No. 1316. P. R. C. 22. Described by Diller in Bull. 150, p. 90.

D. Middle Cambrian shale, Coosa Valley, near Blaine, Cherokee County, Alabama. Analysis by H. N. Stokes, record No. 1549.

	A.	B.	C.	D.
SiO_2	41.32	35.53	51.03	55.02
Al_2O_3	20.71	18.23	13.47	21.02
Fe_2O_3	2.59	2.46	8.06	5.00
FeO	5.46	4.81		1.54
MgO	1.91	2.01	1.15	2.32
CaO	9.91	21.17	.78	1.60
Na_2O	7.19	2.53	.41	.81
K_2O	.88	1.08	3.16	3.19
H_2O at 110°		1.40	.81	2.44
H_2O above 110°	8.78	9.00		5.65
TiO_2	.48	.95		.65
P_2O_5	.08	.08	.31	.06
MnO	.17	.13		trace
BaO				.04
SrO				trace
Li_2O				.03
SO_3				.02
S			7.29	
Cl				trace
CO_2	.55	.88		.83
Carbonaceous matter				.32
Fixed carbon			13.11	
Volatile hydrocarbons			3.32	
	100.03	100.26	102.90	100.54
Less O = S			2.74	
			100.16	

OHIO.

Three samples of Utica shale from New Vienna. Collected by Edward Orton. Partial analyses by F. W. Clarke and R. B. Riggs, record No. 731.

	A.	B.	C.
Insoluble	60.17	29.51	25.80
CaO	17.11	33.43	35.27
MgO	1.25	2.16	1.32
CO_2	15.24	27.16	27.40
	93.77	92.26	89.79

Iron and alumina are present in the soluble portions of these shales, the solvent being dilute hydrochloric acid.

MICHIGAN.

Clay slate, sec. 17, T. 43 N., R. 31 W., near Mansfield. Contains principally quartz, white mica, actinolite, rutile, hematite, and carbonaceous matter. Described by J. M. Clements in Mon. XXXVI, pp. 59, 61, 210. Analysis by George Steiger, record No. 1709.

SiO_2	60.28
Al_2O_3	22.61
Fe_2O_3	2.53
FeO	.45
MgO	1.35
CaO	.13
Na_2O	.54
K_2O	5.73
H_2O at 100°	.60
H_2O above 100°	3.62
TiO_2	.69
P_2O_5	.03
MnO	trace
BaO	.04
C	.97
	99.57

WISCONSIN.

Slates of the Penokee-Gogebic series, collected by C. R. Van Hise. A and C are described in Mon. XIX, p. 306, as magnetitic clay slates. Analyses by L. G. Eakins, record No. 392.

A. Sec. 6, T. 45 N., R. 2 E.
B. Sec. 1, T. 45 N., R. 1 E.
C. Sec. 4, T. 44 N., R. 2 W.

	A.	B.	C.
SiO_2	53.44	59.73	52.58
Al_2O_3	19.62	22.78	20.76
Fe_2O_3	11.38	.11	12.17
FeO	5.35	5.98	4.08
MgO	1.58	2.94	1.33
CaO	.42	.53	.30
Na_2O	2.61	1.41	.37
K_2O	1.73	3.48	4.87
H_2O	4.07	3.28	3.43
P_2O_5	trace	....	....
MnO	trace	.09	.21
Li_2O	trace	....	trace
	100.20	100.33	100.10

COLORADO.

Shales from the Pueblo quadrangle, collected by G. K. Gilbert.
A, B. Near Nushbaum Spring.
C. Salt Creek.
D. Head of Rock Creek.
E. Near Rush Creek.
Analyses by George Steiger, record No. 1466.

	A.	B.	C.	D.	E.
SiO_2	60.80	51.69	60.60	63.60	45.89
Al_2O_3	15.63	16.50	16.42	16.74	13.24
Fe_2O_3	4.62	7.90	4.95	4.63	3.88
MgO	2.73	2.10	1.43	1.19	2.12
CaO	1.63	4.41	1.61	.68	12.09
Na_2O	1.45	2.07	.92	.29	.47
K_2O	2.55	2.68	2.98	2.92	2.31
H_2O at 100°	3.19	3.02	3.91	2.88	1.38
H_2O above 100°	4.16	6.00	5.72	5.99	4.16
TiO_2	.47	.66	.35	.66	.52
P_2O_5	.10	.22	.31	.16	.17
CO_2	....	3.19	....	....	10.38
Organic matter	2.87	.53	.84	.46	3.47
	100.20	100.97	100.04	100.20	100.08

Calcareous shales from Fairplay, Park County. Partial analyses, by W. F. Hillebrand, made in the Denver laboratory.

	F.	G.
Insoluble	68.72	35.14
Fe_2O_3, Al_2O_3, etc	2.10	....
FeO, MnO	....	2.10
MgO	5.72	12.55
CaO	9.06	19.34
H_2O	1.01	.73
CO_2, calculated	13.41	30.28
	100.02	100.14

CALIFORNIA.

Cretaceous shales from Mount Diablo. Described by Turner and Melville, Bull. Geol, Soc. Amer., vol. 3, pp. 383–414. Anlayses by W. H. Melville, made in the laboratory at San Francisco, except F (record No. 1166), which was done in the Washington laboratory.

A. Brownish black, resinous. From Bagley Canyon.

B. Slate colored, soft, friable, little altered. From near Bagley Creek.

C. Same locality as B, less friable, but considerably altered.

D. Slate colored, friable. From Arroyo del Cerro.

E. Very friable. Same locality as D.

	A.	B.	C.	D.	E.
SiO_2	56.66	53.65	49.14	25.05	40.17
Al_2O_3	17.64	17.64	16.91	8.28	12.76
Fe_2O_3	.49	4.06	4.39	.27	2.10
FeO	5.22	3.72	3.82	2.41	3.56
MgO	3.50	5.15	5.43	2.61	15.42
CaO	1.67	2.27	3.28	27.87	4.24
Na_2O	2.17	2.53	4.67	undet.	.57
K_2O	2.27	2.22	1.53	undet.	1.36
H_2O at 100°	3.01	3.95	3.39	1.44	9.19
H_2O above 100°	5.92	4.57	6.97	2.86	6.73
P_2O_5	.15	.23	.24	.08	.08
NiO	....	trace	trace	trace	trace
MnO	.19	.01	.22	4.11	.16
CO_2	....	....	....	24.20	3.48
SO_3	.93	....	....	....	....
	99.82	100.00	99.99	99.18	99.82

F. Neocomian shale, altered, light brown, friable. From near Arroyo del Cerro.

G. Calcareous shale, near Arroyo del Cerro. Hard, compact, dark colored. Very much altered.

H. Red shale, metamorphic area at head of Bagley Creek.

I. Silicified shale or phthanite, same locality as H.

J. Clay slate, near the head of Yaqui Gulch, in Mariposa County. Described by Turner in Bull. 150, p. 342. Contains grains of quartz and feldspar, abundant carbonaceous particles, a chloritic substance (?), and a fibrous alteration of sillimanite (?). Analysis by George Steiger, record No. 1643.

	F.	G.	H.	I.	J.
SiO_2	45.64	44.56	69.98	93.54	60.35
Al_2O_3	15.42	3.12	11.69	2.26	17.62
Fe_2O_3	3.40	1.27	6.23	.48	5.64
FeO	3.73	5.21	1.08	.79	2.20
MgO	4.62	3.39	1.29	.66	1.04
CaO	8.11	12.70	.38	.09	.45
Na_2O	3.13	3.09	.73	.37	1.00
K_2O	1.86	.88	3.72	.51	3.16
H_2O at 100°	8.74	1.41	1.03	.21	1.02
H_2O above 100°		6.24	2.92	.72	4.36
TiO_2					.75
P_2O_5	.27	.16	.05		.17
Cr_2O_3	.12				
MnO	.33	trace	.49	.23	none
BaO					.12
CO_2	4.59	17.62			none
SO_3					.05
Cl					.01
F					trace
C					1.72
	99.96	99.65	99.59	99.86	99.76

CLAYS, SOILS, ETC.

MASSACHUSETTS.

Clays and soils from Marthas Vineyard, collected by N. S. Shaler. See 7th Ann., p. 303. Analyses by F. W. Clarke, record Nos. 439, 440, 441, 442, 443, 444, 445, 446, 454, and 455. Partial analyses only.

A. Average sample of white clay, east end of Chilmark Cliffs.

B. Average sample of clays, Weyquosque series, Chilmark Cliffs.

C. Average sample of fine clay and soil, east end of Weyquosque Cliffs.

D. Sandy white clay, south end of Gay Head Cliffs.

E. Average sample of fine white clay, south end of Gay Head Cliffs.

	A.	B.	C.	D.	E.
SiO_2	82.95	61.76	70.81	56.19	73.46
Al_2O_3. Fe_2O_3	13.45	25.35	20.67	30.65	19.06
MgO	trace	1.95	1.99	trace	trace
CaO	none	.51	trace	none	none
Na_2O	....	1.83	1.23	....	.70
K_2O	....	3.01	1.67	....	.73
Ignition	3.47	5.76	3.39	10.79	6.36
P_2O_5	none	trace	none	none	none
SO_3	....	....	....	2.45	none
	99.87	100.17	99.76	100.08	100.31

F. Average sample of clay, north end of Gay Head Cliffs.

G. Average sample of southernmost red clays, Gay Head.

H. Brown clay, south of light-house, Gay Head Cliffs.

I. Average sample of red clay from the greensand, north end of Gay Head.

J. Pyritiferous clay, central part of Gay Head section.

	F.	G.	H.	I.	J.
SiO_2	49.19	57.50	56.62	55.93	72.74
Al_2O_3, Fe_2O_3	39.77	31.21	31.24	33.51	21.46
MgO	trace	.20	1.97	.19	trace
CaO	none	.19	trace	none	none
Na_2O	....	.40	.40	undet.	....
K_2O	....		2.76	undet.	....
Ignition	11.47	9.83	7.57	9.98	5.69
P_2O_5	none	none	none	none	none
	100.43	99.33	100.56	99.61	99.89

NEW YORK, PENNSYLVANIA, DELAWARE.

A. Clay, near Richfield Springs, New York. Partial analysis by Charles Catlett, record No. 946.

B, C. Clays, Northumberland County, Pennsylvania. Analyses by Charles Catlett, record No. 952.

D. Kaolin, Hockessin, Delaware. P. R. C. 149.

E. Portion of D insoluble in sulphuric acid.

F. Portion of D soluble in sulphuric acid.

Analyses D, E, and F by George Steiger, record No. 1626.

	A.	B.	C.	D.	E.	F.
SiO_2	49.65	65.97	59.16	48.73	29.55	19.18
Al_2O_3	23.82	20.37	18.68	37.02	18.44	18.58
Fe_2O_3		2.75	10.32	.79	.27	.52
MgO	trace	.52	.67	.11	trace	.11
CaO	6.48	.64	.52	.16	.02	.14
Na_2O	undet.	.05	.11	.04	.02	.02
K_2O	undet.	3.32	3.35	.41	.41	none
H_2O at 100°	16.18	6.28	6.87	.52	....	....
H_2O above 100°				12.83	6.84	5.99
TiO_2	....	....	....	.17	.11	.06
P_2O_5	....	....	....	.03	undet.	undet.
	96.13	99.90	99.68	100.81	55.66	44.60

MARYLAND.

Clays from the Matawan formation, received from W. B. Clark. Analyses by George Steiger, record No. 1684.

A. Below Barnard's wharf, near Betterton, Kent County.
B. Severn River, below Round Bay, Anne Arundel County.
C. Magothy River near Wilson's wharf, Anne Arundel County.
D. Fort Washington Bluff.

	A.	B.	C.	D.
SiO_2	73.47	87.15	82.86	73.02
Al_2O_3 *a*	12.69	6.46	6.49	10.00
Fe_2O_3	4.62	2.15	3.54	4.78
MgO	.59	.27	.52	.90
CaO	.15	.10	.29	.57
Na_2O	.09	.14	.16	.59
K_2O	1.55	.90	1.16	1.92
H_2O at 100°	.89	.32	.69	1.09
H_2O above 100°	3.85	1.90	2.24	3.07
SO_3	.19	none	.21	1.04
	98.09	99.39	98.16	96.98

a Titanic and phosphoric oxides not separated.

No carbonates present. Sulphides undetermined.

VIRGINIA, NORTH CAROLINA.

A. Residual clay from decay of Trenton limestone, Lexington, Virginia. Described by Russell in Bull. 52. Analysis by R. B. Riggs, record No. 373. See also analysis of the limestone.

B. Residual clay from limestone, Staunton, Virginia.

C. Portion of B soluble in weak hydrochloric acid.

D. Insoluble portion of B. Analyses B, C, and D by George Steiger, record No. 1630. See also analysis of limestone.

E. Decomposed dolerite, near Wadesboro, North Carolina. Described by Russell in Bull. 52. Analysis by T. M. Chatard, record No. 327.

F. Residual clay from decay of chloritic schist, Cary, 8 miles west of Raleigh, North Carolina. Analysis by R. B. Riggs, record No. 364. Described by Russell in Bull. 52.

	A.	B.	C.	D.	E.	F.
SiO_2	43.07	55.90	3.09	52.81	39.55	54.54
Al_2O_3	25.07	19.92	3.96	15.96	28.76	26.43
Fe_2O_3	15.16	7.30	6.25	1.05	16.80	9.04
FeO		.39	.30	.09		
MgO	.03	1.18	.43	.75	.59	
CaO	.63	.50	.30	.20	.37	
Na_2O	1.20	.23	.20	.03	undet.	
K_2O	2.50	4.79	.28	4.51	undet.	
H_2O at 110°	12.98	2.54			13.26	9.87
H_2O above 110°		6.52	2.10	4.42		
TiO_2		.20	.04	.16	.64	
P_2O_5		.10	.04	.06	.10	
Cr_2O_3					trace	
MnO		none			trace	
CO_2		.38	.38	none		
	100.64	99.95	17.37	80.04	100.07	99.88

SOUTH CAROLINA, GEORGIA.

A, B, C. Clays, near Augusta, Georgia. Partial analyses by George Steiger, record No. 1395.

D. Kaolin, Aiken, South Carolina. Analysis by Steiger, No. 1472.

	A.	B.	C.	D.
SiO_2	60.24	61.36	60.70	44.94
Al_2O_3	26.72	29.04	29.24	39.18
Fe_2O_3				.52
MgO	present	present	present	....
CaO	.88	.76	.68	....
Alkalies	undet.	undet.	undet.	....
H_2O at 100°	6.28	7.46	6.74	.47
H_2O at 200°				.20
H_2O at 300°				.27
H_2O, ignition				13.38
TiO_2	....	....	....	.65
P_2O_5	....	....	....	.12
	94.12	98.62	97.36	99.73

FLORIDA.

A. Hammock clay, Melborne Creek. Collected by N. S. Shaler. Partial analysis by L. G. Eakins, record No. 881.

B. Clay, Tampa.

C. Clay, Lakeland.

B and C collected by W. H. Dall. Analyses by L. G. Eakins, record No. 1255, partial.

	A.	B.	C.
SiO_2	38.04	70.78	80.39
Al_2O_3, Fe_2O_3	27.19	11.33	15.03
MgO	.46	....	....
CaO	10.73	2.18	1.22
H_2O	[a] 23.61	14.55	4.34
	100.03	98.84	100.98

[a] Includes some CO_2.

Clays collected by G. H. Eldridge.

D, E. From the Sandlin place, 2 miles southeast of Marion, Hamilton County.

F. From Richmond's, 6 miles south of Leesburg, Lake County.

G, H. From Bartow Junction.

Analyses D, E, and F by H. N. Stokes, record No. 1493; G and H by George Steiger, No. 1545.

	D.	E.	F.	G.	H.
SiO_2	15.68	78.23	84.41	79.99	79.48
Al_2O_3	.61	7.30	11.02	10.82	12.14
Fe_2O_3	.45	1.85	trace	3.25	2.64
FeO	....	....	....	.25	.09
MgO	17.28	2.11	trace	.07	.07
CaO	26.11	1.60	.20	.23	.31
H_2O at 100°	1.97	[a] 8.48	[a] 4.25	.90	.86
H_2O above 100°				4.09	4.73
P_2O_5	trace	trace	trace	....	....
CO_2	37.90	....	....	none	none
	100.00	99.57	99.88	99.87	100.32

[a] Includes a little CO_2.

I. "Filtering clay," Ocala. Received from D. T. Day. Analysis by H. N. Stokes, record No. 1738.

SiO_2	36.73
Al_2O_3	27.78
Fe_2O_3	3.21
MgO	.64
CaO	.81
Na_2O	none
K_2O	.42
H_2O at 110°	7.38
H_2O above 110°	12.14
TiO_2	1.27
P_2O_5	5.54
CO_2	none
Organic matter	3.61
	99.53

ALABAMA, MISSISSIPPI.

A. Kaolin, Greenville, Alabama. Contains about 40 per cent of kaolin, with fragments of quartz, feldspar, and mica. Analysis by T. M. Chatard, record No. 1148.

B. Residual clay from decay of Knox dolomite, Morrisville, Alabama. Described by Russell in Bull. 52. Analysis by W. F. Hillebrand, record No. 797. See also analysis of the dolomite.

C. Loess from Vicksburg, Mississippi. Described by Chamberlin and Salisbury, 6th Ann., p. 282. Analysis by R. B. Riggs, record No. 294.

	A.	B.	C.
SiO_2	69.84	55.42	60.69
Al_2O_3	19.91	22.17	7.95
Fe_2O_3	.90	8.30	2.61
FeO		trace	.67
MgO	.28	1.45	4.56
CaO	.07	.15	8.96
Na_2O	.21	.17	1.17
K_2O	2.14	2.32	1.08
H_2O at 110°	.06	2.10	
H_2O, ign	6.72	7.76	1.14
TiO_2			.52
P_2O_5			.13
MnO	trace		.12
CO_2			9.63
C, organic			.19
SO_3			.12
Cl			.08
	100.13	99.84	99.62

ILLINOIS, IOWA, MINNESOTA.

A, B. Clays from Henry County, Illinois. Analyses by T. M. Chatard, record No. 144.

C. Loess, a stratum overlying residuary clay, 350 feet above the Mississippi River, near Galena, Illinois. Described by Chamberlin and Salisbury, 6th Ann., p. 282. Analysis by R. B. Riggs, record No. 293. Dried at 100°.

D. Loess, 300 feet above the Mississippi, 3¼ miles northwest of Dubuque, Iowa. Described by Chamberlin and Salisbury (*l. c.*), and analyzed by Riggs, No. 292. Dried at 100°.

E. Tallow clay, lead mine at Lansing, Iowa. Collected by W. P. Jenney. Analysis by H. N. Stokes, record No. 1337. Dried at 100°. Partial analysis.

F. Greenish-gray clay, New Ulm, Minnesota. Analysis by T. M. Chatard, record No. 825.

	A.	B.	C.	D.	E.	F.
SiO_2	46.12	42.58	64.61	72.68	52.08	61.32
Al_2O_3	15.24	12.16	10.64	12.03	23.11	12.27
Fe_2O_3	4.41	3.90	2.61	3.53	9.34	3.62
FeO			.51	.96		4.18
MgO	3.63	4.32	3.69	1.11	2.12	1.76
CaO	8.63	11.33	5.41	1.59	1.04	.99
Na_2O	1.54	1.96	1.35	1.68	undet.	42
K_2O	3.79	3.88	2.06	2.13	undet.	3.59
H_2O	15.57	18.64	2.05	2.50	9.80	10.73
TiO_2	.79	.64	.40	.72		.66
P_2O_5	.08	.10	.06	.23		.27
MnO	.28	.09	.05	.06		.27
ZnO					trace	
PbO					trace	
BaO						.05
CO_2			6.31	.39		
C, organic			.13	.09		
SO_3			.11	.51		.19
Cl			.07	.01		
	100.08	99.60	100.06	100.22	97.49	100.32

WISCONSIN.

Clays, etc., described by Chamberlin and Salisbury in 6th Ann., pp. 250 and 282. Analyses by R. B. Riggs, record Nos. 259, 260, 261, 262, 290, 295. Dried at 100°.

A. Residuary clay from Dodgeville, 4½ feet below surface.
B. The same, 8½ feet below surface.
C. Residuary clay from near Cobb, 4½ feet below surface.
D. Same as C, 3½ feet below surface.
E. Red, putty-like clay, containing pebbles, Milwaukee.
F. Red pebble clay, Milwaukee.

	A.	B.	C.	D.	E.	F.
SiO_2	71.13	49.59	49.13	53.09	40.22	48.81
Al_2O_3	12.50	18.64	20.08	21.43	8.47	7.54
Fe_2O_3	5.52	17.19	11.04	8.53	2.83	2.53
FeO	.45	.27	.93	.86	.48	.65
MgO	.38	.73	1.92	1.43	7.80	7.05
CaO	.85	.93	1.22	.95	15.65	11.83
Na_2O	2.19	.80	1.33	1.45	.84	.92
K_2O	1.61	.93	1.60	.83	2.36	2.60
H_2O	4.63	10.46	11.72	10.79	1.95	2.02
TiO_2	.45	.28	.13	.16	.35	.45
P_2O_5	.02	.03	.04	.03	.05	.13
MnO	.04	.01	.06	.03	trace	.03
CO_2	.43	.30	.39	.29	18.76	15.47
C, organic	.19	.34	1.09	.22	.32	.38
SO_3	....	....	....	....	.13	.05
Cl	....	....	....	....	.06	.04
	100.39	100.50	100.68	100.09	100.27	100.50

MISSOURI, ARKANSAS.

A. Typical loess, Kansas City, Missouri. Dried at 100°. Described by Chamberlin and Salisbury, 6th Ann., p. 282. Analysis by R. B. Riggs, record No. 291.

B, C, D, E. Tallow clays, Joplin, Missouri. Collected by W. P. Jenney. Analyses by T. M. Chatard, record No. 1210.

F. Tallow clay, Aurora, Missouri. Collected by Jenney. Analysis by Chatard, No. 1210. In analyses B, C, D, E, and F the percentages of bases relate to the portion soluble in hydrochloric acid. Analyses only partial.

	A.	B.	C.	D.	E.	F.
Insoluble		40.64	43.07	39.34	39.62	34.04
SiO_2	74.46					
Al_2O_3	12.26	5.72	7.60	6.17	6.45	10.01
Fe_2O_3	3.25	1.30	1.12	1.16	1.53	3.62
FeO	.12					
MgO	1.12	.27	.32	.27	.30	.25
CaO	1.69	1.80	1.70	2.13	1.77	2.09
Na_2O	1.43					
K_2O	1.83					
H_2O	2.70	17.19	16.74	17.63	16.95	16.96
TiO_2	.14					
P_2O_5	.09					
MnO	.02					
ZnO		32.46	29.43	34.28	33.55	33.49
CO_2	.49					
C, organic	.12					
SO_3	.06					
Cl	.05					
	99.83	99.38	99.98	100.98	100.17	100.46

The following partial analyses by H. N. Stokes, record No. 1260, all relate to tallow clays collected by W. P. Jenney. The same remarks apply as to B, C, D, E, and F.

G. Cave Springs mine, Jasper County, Missouri.

H. Great Western mine, Granby, Missouri.

I, J, K. Woodcock mine, Granby, Missouri.

L. Coon Hollow, Boone County, Arkansas.

Material dried at 103°.

Ark.

	G.	H.	I.	J.	K.	L.
Insoluble	34.89	11.25	2.41	16.17	3.85	18.18
Soluble SiO_2	16.75	32.89	36.71	28.62	37.08	29.02
Al_2O_3	7.38	10.78	8.21	8.93	6.46	6.34
Fe_2O_3	10.34	3.89	2.75	5.98	3.49	4.40
ZnO	14.35	29.54	38.59	26.23	38.90	30.50
CaO	1.55	2.65	2.77	2.01	2.56	1.91
MgO	.35	.90	.78	.46	.42	.75
Ignition	10.37	8.22	7.99	9.19	7.52	8.36
	95.98	100.12	100.21	97.59	100.28	99.46

COLORADO.

A. Loess, Denver.

B. Loess, Highland.

C. Concretion in loess, Wray.

A, B, and C collected by S. F. Emmons, analyses by L. G. Eakins, record No. 1066.

D. Clay, Davis ranch, Pueblo quadrangle.

E. Clay, head of Rock Creek, Pueblo quadrangle.

D and E collected by G. K. Gilbert, analyses by George Steiger, record No. 1457.

	A.	B.	C.	D.	E.
SiO_2	69.27	60.97	70.63	63.52	76.56
Al_2O_3	13.51	15.67	10.43	24.72	8.30
Fe_2O_3	3.74	5.22	2.58	.43	.38
FeO	1.02	.35	.48		
MgO	1.09	1.60	1.13	.13	.24
CaO	2.29	2.77	4.64	.30	.12
Na_2O	1.70	.97	1.29	trace	trace
K_2O	3.14	2.28	2.50	trace	trace
H_2O at 100°	4.19	9.83	3.77	1.58	1.26
H_2O above 100°				8.41	4.40
TiO_2				.68	.60
P_2O_5	.45	.19	.20	trace	.06
MnO	trace	trace			
CO_2	trace	.31	2.59		
Organic matter				.40	8.31
	100.40	100.16	100.24	100.17	100.23

F. From Red Creek Canyon, south part Colorado Springs quadrangle.

G. From 2 miles southeast of F.

H. From near Canyon.

I. Overlying H.

Collected as probable fire clays by G. K. Gilbert. Analyses by George Steiger, record No. 1578. Fe_2O_3 represents total iron. Al_2O_3 includes TiO_2. In I, the ignition includes some CO_2, which is absent from the others.

	F.	G.	H.	I.
SiO_2	85.09	86.79	57.98	69.04
Al_2O_3	6.98	8.29	27.51	14.51
Fe_2O_3	1.10	.75	1.68	3.78
MgO	.27	.13	.32	.73
CaO	.21	.34	.42	1.24
Na_2O	none	none	.03	.08
K_2O	.13	.25	.56	.48
Ignition	6.37	3.78	11.80	10.50
P_2O_5	.06	.05	.06	.07
	100.21	100.38	100.36	100.43

J to K. Supposed fire clays collected in the area of the Apishapa sheet, by G. K. Gilbert. Analyses, partial, by H. N. Stokes, record No. 1503. Titanium present, alkalies undetermined. Analyses made on ignited material, reckoned as 100. The loss on ignition is separately stated below each analysis.

	J.	K.	L.	M.	N.
SiO_2	86.58	78.07	76.96	61.98	93.11
Al_2O_3	12.72	20.22	20.77	37.51	5.56
Fe_2O_3	.45	.89	1.11	.45	1.15
MgO	.11	.26	.32	.09	.10
CaO	.11	....	.71	.19	.32
	98.97	99.44	99.87	100.22	100.24
Ignition	4.75	7.51	7.98	12.51	4.45

	O.	P.	Q.	R.
SiO_2	85.98	85.25	54.93	58.56
Al_2O_3	13.67	11.45	43.65	39.17
Fe_2O_3	.41	2.24	.69	.55
MgO	....	.21	.05	.45
CaO	.21	.26	.64	1.08
	100.27	99.41	99.96	99.81
Ignition	5.07	4.81	16.80	19.58

S. Loess-like alluvium, Golden, Jefferson County.

T. Fire clay, Golden, Jefferson County.

Analyses S and T made by W. F. Hillebrand in the Denver laboratory.

	S.	T.
SiO_2	72.31	50.35
Al_2O_3	12.66	34.44
Fe_2O_3	4.67	.75
MgO	.94	trace
CaO	1.15	....
Na_2O	2.47	.10
K_2O	3.75	.48
H_2O+organic matter	1.80	13.88
P_2O_5	.23	....
	99.98	100.00

WYOMING, UTAH, NEW MEXICO.

A. Loess, Cheyenne, Wyoming. Analysis by L. G. Eakins, record No. 1066.

B. Adobe soil, Salt Lake City, Utah.

C. Adobe soil, Santa Fe, New Mexico.

D. Adobe soil, Fort Wingate, New Mexico.

Analyses B, C, and D by Eakins, Nos. 981, 990.

	A.	B.	C.	D.
SiO_2	67.10	19.24	66.69	26.67
Al_2O_3	10.26	3.26	14.16	.91
Fe_2O_3	2.52	1.09	4.38	.64
FeO	.31	....	....	....
MgO	1.24	2.75	1.28	.51
CaO	5.88	38.94	2.49	36.40
Na_2O	1.42	trace	.67	trace
K_2O	2.68	trace	1.21	trace
H_2O	5.09	1.67	4.94	2.26
P_2O_5	.11	.23	.29	.75
MnO	....	trace	.09	trace
CO_2	3.67	29.57	.77	25.84
SO_3	....	.53	.41	.82
Cl	....	.11	.34	.07
Organic matter	....	2.96	2.00	5.10
	100.28	100.35	99.72	99.97

NEVADA.

A. Grayish clay from Upper Lahontan lake beds, Humboldt River bridge, Mill City.

B. Grayish clay, Lower Lahontan beds, same locality. Analyses by T. M. Chatard, record Nos. 32, 33.

C. Adobe soil, Humboldt. Analysis by L. G. Eakins, record No. 981.

D. Halloysite, pale greenish, Lucia mining district, Elko County. Analysis by George Steiger, record No. 1472.

	A.	B.	C.	D.
SiO_2	56.30	50.70	44.64	42.11
Al_2O_3	16.52	19.01	13.19	33.83
Fe_2O_3	5.08		5.12	.04
FeO				.28
MgO	2.64	3.19	2.96	.30
CaO	5.45	10.26	13.91	.33
Na_2O	2.60	1.91	.59	
K_2O	2.17	2.16	1.71	
H_2O at 100°	9.78	13.03	3.89	6.54
H_2O at 200°				1.07
H_2O at 300°				1.26
H_2O, ignition				12.04
P_2O_5			.94	trace
MnO			.13	
CuO				2.83
CO_2			8.55	
SO_3			.64	
Cl			.14	
Organic matter			3.43	
	100.54	100.26	99.84	100.63

CALIFORNIA, WASHINGTON, HAWAIIAN ISLANDS.

A. Sandy clay, Owens Lake, California.

B. Blue clay, Owens Lake, California. Analyses by T. M. Chatard, record No. 551.

C. Clay from foot of Rickey Hill, Kittle Falls, Stevens County, Washington. Analysis by W. F. Hillebrand, record No. 1428.

D. Lava soil, Diamond Head, Hawaiian Islands. Analysis by L. G. Eakins, record No. 888.

	A.	B.	C.	D.
SiO_2	53.24	54.92	62.74	32.88
Al_2O_3	10.84	11.25	16.45	12.02
Fe_2O_3	2.59	2.77	2.62	11.52
FeO	.77	.94	1.91	
MgO	5.82	4.91	2.41	11.70
CaO	9.18	8.76	3.68	12.20
Na_2O	2.06	2.10	3.05	undet.
K_2O	2.64	2.77	3.53	undet.
H_2O at 110°	1.41	2.05	2.69	5.30
H_2O at redness	2.73	2.40		
TiO_2	.25	.30		
P_2O_5				.24
MnO	.10	.08	trace	trace
SrO			trace	
CO_2	8.75	7.24	.65	11.41
SO_3	.08	trace		
Cl	.05	trace		.91
	100.51	100.49	99.73	98.18

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DEPARTMENT OF THE INTERIOR

BULLETIN

OF THE

UNITED STATES

GEOLOGICAL SURVEY

No. 169

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

ALTITUDES IN ALASKA

COMPILED BY

HENRY GANNETT

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

LETTER OF TRANSMITTAL.

Department of the Interior,
United States Geological Survey,
Washington, D. C., February 5, 1900.

Sir: I have the honor to transmit herewith, for publication as a bulletin, a list of altitudes in Alaska, drawn mainly from the charts and other publications of the United States Coast and Geodetic Survey and the publications of this office.

Very respectfully,

Henry Gannett,
Geographer.

Hon. C. D. Walcott,
Director United States Geological Survey.

ALTITUDES IN ALASKA.

BY HENRY GANNETT.

Locality.	Authority.	Elevation.
		Feet.
Achilles Mountain	U. S. Coast and Geodetic Survey.	3,027
Adakh Island	do	5,678
Adams Mountains	do	7,600
Agassiz Mountain	do	2,241
Agassiz Peak	do	5,931
Aghik Island (Semidi Islands)	do	250
Aghiyuk Island (Semidi Islands)	do	1,500
Akutan Island (Fox Islands)	do	3,888
Alikhsemit Island (Semidi Islands)	do	300
Amagat Island	do	1,900
Amak Island	do	1,682
Amatignak Island	do	1,921
Ambler Peak	do	3,058
Amlia Island	do	1,900
Amukta Island	do	3,738
Ancon Peak (Woronkofski Island)	do	3,300
Anowik Island (Semidi Islands)	do	650
Anvil Mountain (Annette Island)	do	2,157
Arkell Lake	do	2,700
Arm Mountain	do	2,177
Arthur Peak	do	3,434
Atka Island	do	4,988
Augustine Island	do	[1]3,000
Avatanak (Fox Islands)	do	1,207
Bainbridge Peak	do	3,467
Bald Ridge (Annette Island)	do	2,241
Barlow Mountain (Mansfield Peninsula)	do	2,142
Bay Point Knoll	do	2,108
Beauclerc Peak	do	2,500
Behm Mountain	do	2,867
Bell Island	do	2,500
Bence Mountain	U. S. Geological Survey	4,800
Berry Knoll	U. S. Coast and Geodetic Survey.	894
Berry Peak (Wrangell Island)	do	2,500
Bessie Peak	do	4,130
Between Mountain	do	1,526
Big Diomede Island (Bering Strait)	do	1,759
Big Mountain	do	8,750
Blackburn, Mount	do	12,500
Black Crag	do	5,895
Black Mountain	do	1,883
Black Mountain	do	5,130
Black, Mount	do	12,500
Black Thorn	do	4,010

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[1] Approximate.

Locality.	Authority.	Elevation.
		Feet.
Bobrof Island	U. S. Coast and Geodetic Survey.	1,392
Bohemian Range	do	2,144 2,589 1,784
Boundary Mountain	do	4,805
Buldir Island	do	1,145
Butler Peak	do	1,153
Calder, Mount (Prince of Wales Island)	do	3,371
Campbell Mountains	do	5,500
Cane Mountain	do	6,100
Carlisle Island (Islands of Four Mountains)	do	7,500
Carter, Mount	U. S. Geological Survey	4,700
Cascade	U. S. Coast and Geodetic Survey.	3,900
Case, Mount	do	5,510
Chapeau Mountain	do	2,000
Chenango Mountain (Annette Island)	do	2,987
Chichagof Peak	do	2,600
Chilkat Pass	do	3,100
Chilkoot Pass	do	3,500
Chipp Peak	do	2,532
Chisana Mountain	U. S. Geological Survey	3,200
Chowiet Island	U. S. Coast and Geodetic Survey.	1,200
Chugatch Mountains	U. S. Geological Survey	5,000 to 6,000
Chugul Island	U. S. Coast and Geodetic Survey.	4,300
Clara, Mount	do	6,000
Cleveland, Mount (Islands of Four Mountains)	do	8,156
Coghlan Island	do	436
Cone Mountain	do	2,718
Cook, Mount	do	13,758
Copper Mountain Range	U. S. Geological Survey	4,000 to 6,000
Cosmos Range	U. S. Coast and Geodetic Survey.	3,279
Cove Hill	do	619
Cranberry Peak	U. S. Geological Survey	5,200
Crater Lake (Chilkoot Pass)	U. S. Coast and Geodetic Survey.	3,500
Crater Mountain	do	633
Crillon, Mount	do	15,900
Cross Mountain	do	2,597
D'Agelet, Mount	do	9,708
Dahlgren Peak	do	3,502
Dana Peak	do	4,260
Davison Mountain (Annette Island)	do	2,652
DeLong Peak	do	3,737
Devils Thumb	do	9,062
Dome Mountain	do	2,100
Dome Peak	do	6,500
Drum, Mount	do	13,300
Dry Island	do	2,460
Duke Hill (Duke Island)	do	540
Du Relle, Mount	U. S. Geological Survey	4,300
Dyke Mountain	do	6,700
Eads Peak	U. S. Coast and Geodetic Survey.	4,636
Eagle Crag	do	5,705

Locality.	Authority.	Elevation.
		Feet.
East Peak	U. S. Geological Survey	4,900
Edgecumbe, Mount	U. S. Coast and Geodetic Survey.	2,800
Elbow Mountain	do	4,111
Emmerich, Mount	do	6,940
Entry Peak (Prince of Wales Island)	do	1,400
Ericson Peak	do	4,296
Etolin, Mount	do	3,778
Evans, Mount	U. S. Geological Survey	5,400
Everett Peak	U. S. Coast and Geodetic Survey.	3,645
Fairweather, Mount	do	15,292
Fanshaw, Mount	do	2,818
Fawn Mountain	do	2,112
Fighting John Peak	do	5,078
Figure Four Mountain	U. S. Geological Survey	2,200
Fillmore Peak	U. S. Coast and Geodetic Survey.	3,633
Flag Hill	U. S. Geological Survey	1,200
Flat Mountain	U. S. Coast and Geodetic Survey.	1,800
Fortymile Dome	U. S. Geological Survey	3,900
Fox Hill	U. S. Coast and Geodetic Survey.	563
Francis, Mount	U. S. Geological Survey	4,800
Franklin Peaks	U. S. Coast and Geodetic Survey.	4,314
Do	do	3,909
Fulton Peak	do	3,252
Gable Mountain	do	4,490
Gap Mountain	do	3,400
Gareloi Island	do	5,334
Garrett Peak	U. S. Geological Survey	5,700
Glacier Mountain	U. S. Coast and Geodetic Survey.	4,769
Glacier Mountain	U. S. Geological Survey	6,000
Golden Horn	U. S. Coast and Geodetic Survey.	6,400
Grant Peak	do	5,291
Gray Peak	do	4,694
Great Sitkin Island	do	5,033
Haeckel Hill	do	3,900
Hall Peak	do	3,726
Hamilton, Mount	U. S. Geological Survey	2,000
Hancock Peak	U. S. Coast and Geodetic Survey.	3,851
Harbor Peak	do	2,200
Harold, Mount	do	3,430
Harrison, Mount	do	6,955
Harry Saddle	do	2,088
Hawthorne Peak	do	4,021
Hayes, Mount	U. S. Geological Survey	14,500
Helmick Mountain	do	2,000
Herbert Island (Islands of Four Mountains).	U. S. Coast and Geodetic Survey.	5,291
Hog Back	do	300
Horn Mountain	do	2,929
Howard, Mount (Kuiu Island)	do	2,340
Hump Knoll	do	3,116
Hunt Peak	do	3,494
Iliamna Peak	do	12,066
Insignificant Ridge (Annette Island)	do	2,987
Irving Peak	do	2,169

Locality.	Authority.	Elevation. Feet.
Iskoot Mountain	U. S. Coast and Geodetic Survey.	4,799
Jade Mountains	do	3,500
Jamestown Peak	do	2,940
Janesville Mountain (Annette Island)	do	2,620
Jenkins Peak	do	3,292
Jubilee Mountain	do	6,380
Judy Hill	do	631
Kane Peak	do	3,292
Kasatocki Island	do	1,018
Kateekhuk Island	do	1,200
Kate, Mount	U. S. Geological Survey	4,600
Kates Needle	U. S. Coast and Geodetic Survey.	9,954
Katété Mountain	do	4,170
Keelikhtagikh Island (Semidi Islands)	do	750
Kimball, Mount	U. S. Geological Survey	10,000
Knob	U. S. Coast and Geodetic Survey.	4,250
Koniuji Island (Aleutian Islands)	do	1,113
Korovin Volcano (Atka Island)	do	4,852
Kusilvak Mountain	do	2,449
Kyska Island	do	3,700
Landslide	do	4,798
Lansdowne, Mount	do	6,140
La Perouse, Mount	do	10,740
Laura, Mount	do	7,527
Lazaro, Mount (Duke Island)	do	1,767
Leadville Mountain	do	1,797
Lincoln Peak	do	4,894
Little Sitkin Island (Aleutian Islands)	do	3,585
Lituya Mountain	do	11,832
Lockwood Peak	do	3,510
Logan, Mount	do	9,000
Longfellow Peak	do	2,955
Lorne, Mount	do	6,400
McDonough, Peak	do	2,873
McGrath, Mount	do	6,179
McKinley, Mount	U. S. Geological Survey	20,464
McMillan Mountains	U. S. Coast and Geodetic Survey.	3,500
Madison Peak	do	2,507
Makushin Mountain	do	5,474
Marr, Mount	U. S. Coast and Geodetic Survey.	2,447
Marshall Mountain	U. S. Geological Survey	5,200
Marshall Peak	U. S. Coast and Geodetic Survey.	3,017
Maury Peak	do	5,566
Mayer Peak	U. S. Geological Survey	6,100
Meiklejohn Pass	do	4,500
Mentasta Pass	do	2,300
Michie Mountain	U. S. Coast and Geodetic Survey.	5,540
Miners Range	do	4,000 to 4,500
Missionary Ridge	do	2,450 2,650 2,715 2,851
Moosehorn Mountain	U. S. Geological Survey	5,000

Locality.	Authority.	Elevation.
		Feet.
Moss Mountain	U. S. Coast and Geodetic Survey.	1,631
Mound Hill	do	1,956
Muckacharne	do	1,600
Mud Glacier	do	5,426
Nakat Mountain	do	2,921
Navy Peak	do	3,734
Nichols Hills	do	250
North Quadra Mountain	do	2,353
Notch Mountain	do	1,879
Oratia Mount	U. S. Geological Survey	6,000
Ourand Mount	do	4,300
Parsons Peak	U. S. Coast and Geodetic Survey.	5,500
Patterson Peak	do	4,746
Pelly Mountains	do	5,000 to 7,000
Pinnacle	do	8,346
Pogrumnoi Volcano (Unimak Island)	do	5,523
Porter Peak	do	4,798
Portland Island	do	206
Powell Knob	do	2,655
Purple Mountain (Annette Island)	do	2,447
Putnam Peak	do	3,887
Pyramid Peak	do	4,068
Quay Peak (Chugatch Mountains)	U. S. Geological Survey	5,000
Red Bay Mountain	U. S. Coast and Geodetic Survey.	2,843
Red Mountain	do	2,404
Reverdy Mountains	do	5,485
Rich Mountain	U. S. Geological Survey	5,000
Ripinski, Mount	U. S. Coast and Geodetic Survey.	4,060
Romig, Mount	U. S. Geological Survey	2,500
Rootck Island	U. S. Coast and Geodetic Survey.	3,888
Roundabout Mountain	U. S. Geological Survey	1,000
Round Hill	U. S. Coast and Geodetic Survey.	1,647
St. Elias, Mount	do	18,024
St. Michaels Mountain	do	472
St. Paul (one of Pribilof Islands)	do	633
Sajaca (Tanaga Island)	do	7,103
Sanford, Mount	U. S. Geological Survey	14,000
Sannak Peak (Sannak Island)	U. S. Coast and Geodetic Survey.	1,850
Saranac Peak	do	2,683
Seattle, Mount	do	10,000
Seguam Island	do	2,098
Semichi Islands	do	818
Seminow Hills	do	3,500 to 4,000
Sentinel Peak	do	4,250
Seward Mountains	do	[1] 4,000
Sharp Peak	U. S. Geological Survey	5,900
Shed Mountain	U. S. Coast and Geodetic Survey.	2,620
Shell Hills	U. S. Geological Survey	1,500 to 1,700

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[1] Approximate.

Locality.	Authority.	Elevation.
		Feet.
Shishaldin Volcano (Unimak Island)	U. S. Coast and Geodetic Survey.	8,952
Simpson, Mount	U. S. Geological Survey	5,200
Simpson Mountains	U. S. Coast and Geodetic Survey.	6,500
Snow Cap	do	5,078
Snow Tower	do	7,100
Snowy Mountain	do	5,577
South Island (Semidi Islands)	do	250
South Quadra Mountain	do	1,764
Spirit Mountain	U. S. Geological Survey	3,000
Split Top Mountain	do	2,100
Spuhn Island	do	246
Stephens Mountain	do	331
Stripe Mountain	do	2,300
Stuart Mountain (Stuart Island)	do	483
Sugar Loaf Mountain	do	5,259
Sukhlikh Island (Semidi Islands)	do	200
Summit Glaciers	do	5,700
Summit Peaks	U. S. Geological Survey	5,800
Sunny Mountain	do	4,400
Sunset Island	U. S. Coast and Geodetic Survey.	404
Survey Mountains	do	2,916
Sushitna, Mount	do	5,500
Taku Mountain	do	2,170
Tamgas Mountain (Annette Island)	do	3,684
Tanaga Island	do	6,975
Tangent Peak	do	2,449
Tent Mountain	do	7,100
Terrace Mountain	U. S. Geological Survey	6,000
The Nipples	U. S. Coast and Geodetic Survey.	2,900
The Sisters	do	1,021 1,325 1,308 1,369 1,555 1,680 1,593 1,589 1,350
Thomas, Mount	U. S. Geological Survey	5,400
Thunder Mountain	U. S. Coast and Geodetic Survey.	3,080
Tigalda Island	do	1,207
Tillman, Mount	U. S. Geological Survey	13,300
Tohtankella Mountain	U. S. Coast and Geodetic Survey.	3,000
Trout Hill	do	893
Tsesiuh Mountains	do	3,500
Turner, Mount	do	5,953
Twin Peaks	do	6,638
Vancouver, Mount	do	15,666
Verstovaia, Mount	do	3,216
Villard, Mount	do	5,100
Vsevidof Volcano (Umnak Island)	do	8,000
Wagner, Lake	U. S. Geological Survey	1,900
Warm Spring Mountain	U. S. Coast and Geodetic Survey.	3,370
Washington Peak	do	3,557
Waterfall Peak	do	3,403
Webster Peak	do	3,254

Locality.	Authority.	Elevation.
		Feet.
West Peak	U. S. Geological Survey	5,600
Whipple, Mount	U. S. Coast and Geodetic Survey.	6,033
White Pass	do	2,886
Wilkes Peak	do	3,156
Willoughby Island	do	1,545
Wrangell Peak	do	3,800
Wrangell, Mount	do	17,500
Wright, Mount	do	4,944
Do	do	6,300
Yellow Hill (Annette Island)	do	554
Yenlo Mountain	U. S. Geological Survey	4,000
Young, Mount	U. S. Coast and Geodetic Survey.	5,260
Yukon Hills	do	1,000 to 2,500
Yunaska Island	do	2,864

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DEPARTMENT OF THE INTERIOR

BULLETIN

OF THE

UNITED STATES

GEOLOGICAL SURVEY

No. 170

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

SURVEY

OF THE

BOUNDARY LINE BETWEEN IDAHO AND MONTANA

FROM

THE INTERNATIONAL BOUNDARY TO THE CREST OF THE BITTERROOT MOUNTAINS

BY

RICHARD URQUHART GOODE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

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DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., February 21, 1900.

SIR: I have the honor to transmit herewith a detailed report relating to the survey of the boundary line between Idaho and Montana from the international boundary to the crest of the Bitterroot Mountains.

I wish to make acknowledgment of the valuable services rendered in this connection by Messrs. S. S. Gannett and D. L. Reaburn, in field and office, and by Mr. E. T. Perkins, jr., in the field. Mr. Gannett prepared the greater portion of the material relating to latitude, longitude, base line, azimuth, and triangulation.

Very respectfully,

RICHARD U. GOODE,
Geographer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

SURVEY OF THE BOUNDARY LINE BETWEEN IDAHO AND MONTANA FROM THE INTERNATIONAL BOUNDARY TO THE CREST OF THE BITTERROOT MOUNTAINS.

By Richard U. Goode.

INSTRUCTIONS.

The survey of the boundary line between Idaho and Montana was provided for by the Fifty-fourth Congress in the sundry civil act approved June 4, 1897.

The following correspondence is self-explanatory:

Department of the Interior,
United States Geological Survey,
Washington, D. C., June 5, 1897.

The honorable the Secretary of the Interior.

Sir: In response to your verbal request, I have the honor to transmit herewith suggested instructions relating to the survey of the boundary line between Idaho and Montana.

I am, with respect, your obedient servant,

Chas. D. Walcott, *Director.*

INSTRUCTIONS RELATING TO THE SURVEY OF THE BOUNDARY LINE BETWEEN IDAHO AND MONTANA.

Included in the act making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1898, and for other purposes, is found the following law:

> For surveying that portion of the boundary line between Idaho and Montana beginning at the intersection of the thirty-ninth meridian with a boundary line between the United States and the British possessions, including the retracing of so much of the international boundary line as may be found necessary for the determination of said intersection, then following said meridian south until it reaches the summit of the Bitterroot Mountains, and for locating points on said meridian by triangulation from the Spokane base of the United States Geological Survey, and on the continuation of said boundary line along the Bitterroot Mountains between Idaho and Montana, seven thousand six hundred and fifty dollars, or so much thereof as may be necessary, to be immediately available: *Provided*, That the Secretary of the Interior shall direct that the survey shall be executed under the supervision of the Director of the Geological Survey by such persons as may be employed by or under him for that purpose, and such survey shall be executed under instructions to be issued by the Secretary of the Interior: *Provided further*, That the plats and field notes thereof prepared shall be approved and

certified to by the Director of the Geological Survey, and three copies thereof shall be returned, one for filing in the surveyor-general's office of Idaho, one in the surveyor-general's office of Montana, and the original in the General Land Office.

In carrying out the provisions of the law above quoted three special processes are involved:

First. The accurate location of the thirty-ninth meridian on the ground by triangulation from the Spokane base of the United States Geological Survey, including the retracing of so much of the international boundary line as may be found necessary for the determination of the intersection of the thirty-ninth meridian with the said boundary line, as well as for locating points on the continuation of the boundary between Montana and Idaho along the summit of the Bitterroot Mountains.

Second. The marking on the surface of the ground, by proper monuments, of the boundary as determined.

Third. The preparation of the necessary plats and field notes.

With reference to the above, the following instructions will be observed:

LOCATING THE BOUNDARY.

The Spokane base of the United States Geological Survey is referred to the meridian of Greenwich, and the thirty-ninth meridian above mentioned has for its initial point the meridian of the old Naval Observatory at Washington. By applying the proper correction and referring the thirty-ninth meridian west of Washington to the meridian of Greenwich, the result is that the meridian to be determined as the boundary line between Idaho and Montana is 116° 03′ 02″.30 west of Greenwich.

The triangulation from the Spokane base will be extended eastward so as to accurately locate the intersection of the meridian above mentioned west from Greenwich with the summit of the Bitterroot Mountains. It may be that this identical point can not be located directly by triangulation, but a point as near thereto as may be possible should be so located, and from this the exact point should be determined by careful traverse based on an astronomic or calculated azimuth and distances determined by direct chaining or stadia measurement, whichever may be most practicable.

After the point referred to, namely, the intersection of the meridian 116° 03′ 02″.30 west from Greenwich with the summit of the Bitterroot Mountains, has been determined, the triangulation is to be extended northward, locating as many points as may be practicable as near as may be to the boundary line between Idaho and Montana until the international boundary is reached. From the points so located by triangulation other points exactly on the boundary will be determined by traverse in the manner hitherto mentioned. The international boundary line is supposedly on the forty-ninth parallel of latitude. It will not, however, answer the purpose to rely on the location of this parallel from the Spokane base, but it must be determined with reference to an existing monument or monuments, being carefully retraced until its point of intersection with the meridian is exactly located.

The distance along the international boundary from the nearest monument, or the monument recovered, to the point of intersection will be determined either by triangulation or direct measurement with chain or stadia or a combination of the two methods.

After points as above described have been located on the boundary line between Idaho and Montana from the international boundary to the summit of the Bitterroot Mountains, these points will be joined by true meridian lines, so that a sufficient number of points on the boundary in addition may be determined to fulfill the *conditions made necessary* under the provisions hereinafter mentioned for marking the line. Upon the completion of the survey and marking of the portion of the boundary line coincident with the thirty-ninth meridian, the triangulation will be extended in a southeasterly direction so as to locate points on the continuation of the said boundary line along the Bitterroot Mountains.

All triangulation will be executed in accordance with instructions issued by the Director of the United States Geological Survey under date of February 15, 1897.

In running lines between points located on the boundary the following instructions will be observed:

The instrument used must be a first-class transit instrument, reading to minutes or less, with or without solar attachment, but provided with stadia wires, and must be kept constantly in adjustment. In running the line, double back and fore sights with telescope direct and reversed must be taken, in order to guard against errors resulting from imperfect adjustment of the line of collimation. It is absolutely necessary to follow this method whenever meridian lines are run, in order to avoid errors in the course.

When offset lines are necessary, the notes must fully explain the procedure, and a diagram of such offsets must be inserted after the verbal description.

Observations on Polaris for azimuth must be taken on the line every night, weather and other circumstances permitting, and the record of such observations must be given in detail in the notes in the manner as described in the Manual of Surveying Instructions for the Survey of the Public Lands of the United States, issued by the Commissioner of the General Land Office under date of June 30, 1894.

Temporary marks will be established on the preliminary or random lines between located points, and on reaching a closing point the departure therefrom will be noted. The true line will then be established, and permanent marks placed by shifting the positions of the temporary marks with a swing proportionate to the closure error and distances. Distances along the line will be carried by stadia or chaining, so that it will be possible to locate accurately all monuments established, as well as all topographic and cultural features. The distances thus obtained will be checked in closing from one located point to another.

A full description of all monuments, the character of the timber and soil, the distances to the crossing of all bridges, rivers, lakes, outlines of wooded areas, railroads, roads, trails, and other prominent features will be fully recorded in the field notes, and a sketch of the topographic features adjacent to the boundary line will be made, as well as from each triangulation station on or near the line and from any traverse that may be run in connection with the line. Intersections will be made whenever possible on all important objects susceptible of location.

The magnetic declination will be determined in connection with each transit observation on the line.

MARKING THE LINE.

Monolithic monuments will be placed on the boundary at the following places: Near the Northern Pacific Railway, near the Great Northern Railway, and near the north bank of the Kootenai River. These monuments are to be 6 feet long and 10 inches square, minimum dimensions, and are to be placed in a truly vertical position, set 3 feet in the ground and with their faces directed to the cardinal points. They are to be of undressed stone, except for a space sufficient to cut the words "Idaho" and "Montana" on the west and east sides, respectively, which will be dressed smooth, and the letters shall be 2 inches high, of proportionate width and of the style known as Egyptian. The same kind of monuments will be placed on the line at the international boundary and at the summit of the Bitterroot Mountains if it shall be found practicable to transport them in one mass, otherwise they will be prepared in the quarry in every respect similar to those mentioned above and will then be sawed into sections of such size as to be readily transported on pack mules to their destinations. They will then be firmly and securely cemeted with Portland cement and established in the same manner as the other stone monuments. The monument on the international boundary in addition to having the inscription "Idaho" and "Montana" on the west and east sides, respectively, will have "Canada" inscribed on the north.

Intermediate between the stone monuments above described will be placed at prominent summits, road, trail, or stream crossings, at distances not exceeding a mile apart, and intervisible whenever possible, wrought-iron posts 6 feet in length, 3 feet of which shall be above ground and 3 feet below the surface, with a brass cap similar in general design to the standard iron posts used by the United States Geological Survey. The cap surmounting the post will be inscribed as below, the line cut on the cap being coincident with the boundary line:

IDAHO
BOUNDARY

LINE
MONTANA

Under each post will be placed a stone marked with charcoal or a vial filled with ashes.

It is assumed that generally a soil surface for the insertion of the stone or iron posts can be found sufficiently near the points it is desired to establish the monuments. If, however, the exact point should fall on rock at the international boundary or the summit of the Bitterroot Mountains, a hole will be chiseled in the rock to a depth of about 8 inches and a little larger than the base of the monument. Into this hole the monument will be firmly cemented with the best Portland cement. If the point for the location of one of the iron posts should fall on a rock surface, a copper plug similar to that used by the United States Geological Survey will be cemented in the rock and a truncated conical mound of stone, not less than 2½ feet high and 5 feet broad, will be placed to the north of the point at a distance of 4 feet from it. The copper plug will be stamped as follows: $\frac{\text{MONT.}}{\text{IDA.}}$ and will be properly oriented.

When suitable bearing trees are found within a distance of 100 feet of a stone monument or iron post, they must be marked on the side facing the corner in the manner prescribed in the manual for special corners.

In addition, each iron post will be witnessed, when possible, by mounds of earth or stone, one in Idaho and one in Montana, the material for the mounds to be taken from pits, one north and one south of the post, dug crosswise of the line. The pits will be 3 feet east and west, 2 feet north and south, and 1 foot deep, and their centers, as well as the centers of the mounds, will be 4 feet from the center of the iron post.

PLATS AND FIELD NOTES.

Special attention is called to the provisions of the law relating to plats and field notes.

All plats and field notes shall be approved and certified to by the Director of the Geological Survey, and four copies thereof shall be returned—one for filing in the surveyor-general's office of Idaho, one in the surveyor-general's office of Montana, one in the office of the Geological Survey, and the original in the General Land Office. All field notes must be transcribed on a typewriting machine.

The results of the topographic notes will be embodied in a map which will be drawn on a scale of 1 inch to a mile. Detailed diagrams of the points on the international boundary and at the intersections of the Bitterroot Mountains will be made.

All parties engaged in the prose[illegible]his survey will be sworn before an officer duly qualified to administer oa[illegible] the beginning and end of the survey. The oath of the chief of party must be taken either before the clerk of the district court or a United States commissioner. (See Manual, page 64.)

Department of the Interior,
Washington, June 5, 1897.

The Director of the Geological Survey.

Sir: Your letter of the 5th instant has been received, submitting for my consideration and approval instructions relating to the survey of the boundary line between Idaho and Montana, for which provision was made in the sundry civil appropriation bill, approved June 4.

The instructions in question have been approved by indorsement thereon and are herewith returned.

Very respectfully,
C. N. Bliss, *Secretary.*

Department of the Interior,
United States Geological Survey,
Washington, D. C., June 7, 1897.

Mr. R. U. Goode, *Geographer.*

Sir: The execution of the necessary work in connection with the survey of the boundary line between Idaho and Montana, as provided for in the sundry civil bill for the fiscal year 1897-98, is placed under your supervision.

This work will be performed in accordance with instructions approved June 5, 1897, by the Secretary of the Interior.

The sum of $7,650 has been appropriated in this connection, and you are authorized, within the limits of the above appropriation, to employ such temporary field assistants as may be necessary for the proper prosecution of the survey, and to make such journeys and to order your assistants to make such journeys as may be necessary in carrying forward the work.

Very respectfully,
Chas. D. Walcott, *Director.*

BOUNDARY LINES.

Territorial and State lines in the northwestern portion of the United States have undergone many changes. Originally this area was included partly in Louisiana and partly in Oregon, the dividing line being the crest of the Rocky Mountains.

Oregon Territory was organized August 14, 1848. Its area at that time included the present States of Oregon, Washington, and Idaho, and portions of Wyoming and Montana. The Territory of Nebraska, formed from a portion of the Louisiana Purchase, was organized May 30, 1854. Its original area extended from Minnesota on the east to the continental watershed on the west, and included the existing State of Nebraska and portions of Colorado, Wyoming, Montana, North Dakota, and South Dakota. The Territory of Dakota was formed March 2, 1861, from parts of the State of Minnesota and the Territory of Nebraska, and on March 3, 1863, the Territory of Idaho was formed of portions of Nebraska, Dakota, and Washington, the latter having been organized March 2, 1853, from a portion of the Territory of Oregon. Originally, Idaho contained about 324,875 square miles, but in 1864 it was reduced 146,080 square m[illegible]he formation of the Territory of Montana, which was taken entirely from Idaho, and in 1868 it was further reduced by the formation of the Territory of Wyoming, almost the whole of which (93,995 square miles) was taken from Idaho. Montana to-day stands as originally organized, while Idaho contains about 84,800 square miles.

The present boundaries of Montana are described as follows:

> Beginning at the intersection of the twenty-seventh meridian of longitude with the boundary line between the United States and the British possessions, it follows said meridian south to the forty-fifth parallel of latitude; thence west on this parallel to the thirty-fourth meridian; south on the thirty-fourth meridian to the point where that meridian intersects the continental watershed; thence westward and northwestward, following the line of the continental watershed and the summit of the Bitterroot Range to its intersection with the thirty-ninth meridian; thence north on the thirty-ninth meridian to the boundary line between the United States and British possessions, and east on that boundary line to the point of beginning.

The present boundaries of Idaho are described as follows:

> Beginning at the intersection of the thirty-ninth meridian with the boundary line between the United States and the British possessions, it follows said meridian south until it reaches the summit of the Bitterroot Mountains; thence southeastward along the crest of the Bitterroot Range and the Continental Divide until it intersects the meridian of thirty-four degrees of longitude; thence southward on this meridian to the forty-second parallel of latitude; thence west on this parallel of latitude to its intersection with a meridian drawn through the mouth of the Owyhee River; north on this meridian to the mouth of the Owyhee River; thence down the midchannel of the Snake River to the mouth of the Clearwater; and thence north on the meridian which passes through the mouth of the Clearwater to the boundary line between the United States and the British possessions, and east on said boundary line to the place of beginning.

The boundary under discussion is the common one mentioned above.

In the United States State boundary lines may be grouped in two general classes:

First. Those that are defined by some natural physical feature, such as an ocean or a lake shore, the channel or bank of a stream, the summit of a range of mountains, or a watershed.

Second. Those that are defined by imaginary lines which must be traced on the earth's surface by astronomic or mathematical processes. Such a line may be a meridian of longitude, a parallel of latitude, a line between two points (such as a portion of the eastern boundary of Nevada, which is from the intersection of the one hundred and twentieth meridian and the thirty-ninth degree of latitude to a point on the Colorado River where it intersects the thirty-fifth degree of latitude), a line defined by azimuth and distance or a number of such lines consecutively joined (such as the boundary line between Maine and New Hampshire), a line determined by a given direction from a certain point terminating at its intersection with some other line

CREST OF BITTERROOT MOUNTAINS.

(such as a portion of the western boundary of Idaho, which runs from a point in the channel of Snake River opposite the mouth of the Clearwater due north to the thirty-ninth parallel of latitude), or a tangent or arc of a circle (such as the western and northern boundary of Delaware).

Generally speaking, boundary lines of the first class need no monuments to indicate their location, while those of the second class must be perpetuated by marks of some kind after their positions have been determined.

The boundary line between Idaho and Montana is made up of two sections, falling into the two classes mentioned. The first section is that part defined as the thirty-ninth meridian, between the international boundary and the summit of the Bitterroot Mountains; and the second section is the sinuous line corresponding to portions of the crest of the Bitterroot and Rocky mountains, this line beginning at the intersection of one meridian line and terminating at another meridian line. The first section has been located and marked by monuments, as will appear hereafter. The second section is considered to be adequately determined, since it follows a watershed, and its terminal points have been marked—the northern one by the results of the survey under discussion, and the second by the results of the survey of the western boundary of Wyoming, which line follows the thirty-fourth meridian from the forty-first parallel to the crest of the Rocky Mountains. The survey of the latter line was authorized by an act of Congress approved March 3, 1873, and was made, under contract, by Alonzo V. Richards, astronomer and surveyor, in June, July, August, and September, 1874. The following is a description of the corner of Idaho and Montana on this line, as taken from the report of the survey above referred to:

> At 245 miles 56 chains and 50 links the corner of Idaho and Montana was established on the crest of the Rocky Mountains. It is commemorated by a pine post 11 feet long by 15 inches in diameter, 3¼ feet in the ground, marked on north face "34° W. L., 1874;" on south face, "246 m. 56 chs. 50 lks.;" on east face, "Wyoming;" on southwest face, "Idaho;" on northwest face, "Montana;" and is squared 2 feet at the upper end in the shape of a pentagon. The point is further perpetuated by a stone in the bottom of the pit in which this post was set, marked "A. V. R," with several charred blocks. A conical mound of earth and stone was raised 4 feet high by 7 feet in diameter, with a pit in the corner of each of the three Territories 3 feet square by 2 feet deep. Then, on the top of the mound, on the east side, was placed a flat sandstone, marked "Wyoming;" another on the southwest side, marked "Idaho," and one on the northwest side, marked "Montana." Nineteen pine trees are noted as witnesses to this post.

It will be noted that the law provides for locating points on the continuation of the boundary line along the Bitterroot Mountains between Idaho and Montana. It was not possible to extend the triangulation beyond the southern extremity of the meridional portion of the boundary line, on account of the available funds not being sufficient for the purpose. In fact, the appropriation made would not have been adequate for the work that was accomplished if it had not been possible to utilize, in connection with the boundary line, work done under other appropriations. In this manner about 50 miles of the boundary were accurately located in connection with the survey of the Hamilton quadrangle, a portion of which is embraced within the limits of the Bitterroot Forest Reserve.

The crest line of the Rocky and Bitterroot mountains between Idaho and Montana is generally a clearly defined summit or watershed, so that no serious question need arise as to its identification as an inter-State boundary. (See Pl. I.) In a few localities, notably in some of the passes, there are morasses of small extent out of which the water flows or seeps in both directions. If the question of placing monuments to mark this line ever arose, the location of monuments in such swampy localities as are found to exist would probably fulfill all necessary requirements. It is, however, very desirable that topographic maps of the adjacent territory be prepared. Such maps would clearly differentiate the true summits from the diverging spurs, and prevent any possible misconception as to the location of the line. After these maps had been prepared there would be no further question of surveying, but merely one of placing monuments, should this be considered necessary.

It frequently happens, as the result of greater or less relative erosion or uplifting, that spurs have an elevation higher than that of the main watershed, and this is remarkably the case in certain portions of the Bitterroot Mountains. In fact, in those portions where detailed examinations have been made all of the higher points of the range are uniformly from 6 to 8 miles east of the present divide, and it is probably true that this divide, in the course of geologic time, has retreated from an irregular line which passed through these high points. This, if true, is due partly to the fact that the waters of the Bitterroot River draining to the eastward have a greater relative rate of fall, and consequently greater erosive power, than had the waters flowing westward through the Clearwater, and thus the territory tributary to the former is gradually being captured by and added to that of the latter.

ACCOUNT OF OPERATIONS.

The work in connection with the boundary line extended through portions of three field and office seasons.

The act providing for the survey of the boundary line was approved June 4, 1897, and Mr. E. T. Perkins, jr., topographer, was immediately detailed for field work in connection with the triangulation. Mr. Perkins left the city of Washington on June 10, and proceeded to Spokane, Washington, by way of Boise, Idaho, stopping at the latter place to arrange for the transportation of certain property to

A. CABINET RANGE

B. SUMMIT OF CABINET RANGE SHOWING POINTS TOUCHED BY BOUNDARY LINE (A AND B)

be used in connection with the work. The party was organized at Spokane, and at first consisted of only a packer and a cook, but was afterwards increased by the addition of a field assistant, when angle observations were begun. When occasion required, for instance in clearing the timber for a triangulation station, extra men were hired by the day. Transportation was at first by saddle and pack animals alone, but later a light spring wagon was added to the outfit.

The work was greatly retarded by smoke during the summer, which was at times so dense as to render observations impossible, and by unusually early storms in the fall. All operations were entirely suspended about October 1, the snow being so deep as to render practically impossible the ascent of the peaks used as triangulation stations. The season's work consisted in extending the triangulation from the Spokane base eastward, through a longitudinal interval of about 70 miles, to the boundary line. Fifteen stations were erected, nine of which were occupied, and one observation for azimuth was made. Another object accomplished during the field season was the identification on the ground of the Mooyie Trail monument, which had been established by the Northwestern Boundary Commission. This monument was about 8½ miles west of the boundary line between Idaho and Montana, and was the nearest monument or mark of any kind on or near the international boundary that could be identified. Further reference will be made to the Mooyie Trail monument.

After the party was disbanded, Mr. Perkins proceeded to California for duty. During the winter the office work pertaining to the triangulation was done under the direction of Mr. S. S. Gannett. Three figures were adjusted by least squares, and the geodetic positions of nine points were computed. One of the stations, Divide, was found to be 6,072 feet east of the Idaho-Montana boundary line, and another station, Scotchman, was found to be 7,842 feet west of it.

Field operations were resumed in June, 1898, two parties being organized, one for the extension and completion of the necessary triangulation, the other for running the random line northward from the point determined as the intersection of the thirty-ninth meridian west from Washington with the crest of the Bitterroot Mountains.

Mr. Perkins continued the triangulation, and the line party was organized by Mr. S. S. Gannett, topographer, with Mr. D. L. Reaburn, as transit man, the latter assuming charge of the party after the work was started.

Mr. Perkins extended his work of the preceding year northward to the international boundary, occupying nine new stations and reoccupying four old ones. A high signal was erected over the Mooyie Trail monument, and this point was located. Unfortunately the character of the country was such that it was impossible to get a location by triangulation near the northern terminus of the interstate boundary line.

Mr. Gannett was instructed to carefully examine the topographic features of the country adjacent to the triangulation station Divide, in order to determine whether it was on the true summit of the Bitterroot Mountains, and then, by traverse from the Divide station, to locate the exact point on the summit from which, as the initial point, the random line should be projected northward. Observations for azimuth were obtained at Divide, the details of which will appear hereafter, and also at the end of the traverse line. This traverse was run along the divide westward through a longitudinal interval which was supposed to be 6,072 feet, but, unfortunately, owing to an error in the field computations, the location of the initial point was made 177 feet too far east. This error was discovered in the office, and in the adjustment of the random line it was entirely eliminated from the final results.

Work on the random line was commenced July 11 by the party under Mr. Reaburn, which consisted of one recorder, two rodmen, two packers, three axmen, and a cook. The region traversed was along the entire line very rough and generally covered with timber. There were few roads or open trails, and the transportation problem was a difficult one. A pack train was provided, and it was generally necessary to make long detours and to cut out trails in order to establish camps at convenient points near the line. Toward the close of the season a great deal of snow was encountered on the high ridges, the party narrowly escaping being snowed in without provisions. The survey of the random line was completed to the vicinity of the international boundary on October 31 in snow 2½ feet deep.

Horizontal and vertical distances along the entire line were obtained by stadia measurements. The total rise and fall of the boundary line was about 63,000 feet, the average length of sights 350 feet, length of line about 72 miles, number of transit stations 1,051, and number of azimuth stations 17.

At the conclusion of the field season Mr. Perkins returned to the office and Mr. Reaburn was ordered to field duties elsewhere.

During the office season of 1898–99, after the triangulation had been finally computed, an adjustment of the stadia work to the triangulation was made, and tables were prepared showing the exact latitudinal and longitudinal corrections to be applied at each station of the random line. Elevations were also computed from the vertical angles for each transit station. Six sheets on mounted drawing paper, each sheet extending through a latitudinal interval of 10′, were then prepared. On these sheets was drawn the boundary line in its true position, and all topographic features which had been located from the random line were indicated. Such elevations as would be useful in sketching contours were also placed on the sheets, and the sheets thus arranged were used for sketching the topography adjacent to the line.

Mr. Reaburn resumed field operations about the middle of June,

A. CAMP SOUTH OF SUMMIT OF CABINET RANGE.

B. QUARTZITE SLATE NEAR SUMMIT OF SCOTCHMAN PEAK

1899, the party as organized being similar to that of the preceding season. The field work which remained was to remeasure a portion of the line, place the monuments, cut out the true line, and secure additional data for the map.

The line was divided into four sections, reference to which will be made hereafter. Three of them were controlled by triangulation, but the fourth, or northernmost section, not being so controlled, it was decided to remeasure that section with the stadia, and also to make a careful comparative measurement with a steel tape. The measurement with the steel tape served not only to check this section of the line, but was also used as a basis of comparison with the stadia measurements and to determine a stadia factor, which was afterwards applied to all of the stadia work.

The measurements of the northernmost section were first made, and the northern terminal point of the line determined. The party then started southward, and the monuments were established, marked, and witnessed in accordance with the instructions. The topography was also sketched, but as the territory through which the line ran was for the most part covered with timber, it was impossible, without delaying the work beyond the limit of the available funds, to cover more than a narrow belt. This work was completed October 5, 1899, and after a short service in another locality Mr. Reaburn reported to the office in Washington for the preparation of the final notes and plats.

LATITUDE, LONGITUDE, BASE LINE, AZIMUTH, AND TRIANGULATION.

In the following pages is given a short account of the methods employed in establishing what may be termed "the control" for the boundary line.

By combining the results of the latitude, longitude, and azimuth observations with the base-line measurement, the position on the earth's surface and the length and true direction of a line were determined. Through a system of triangulation based on the line thus established the positions of points near the boundary line were computed, as well as the distances and directions between these points.

LATITUDE.

The new county court-house at Spokane having been built very close to the longitude pier of the United States Coast and Geodetic Survey of 1888, the latter could not be used as a latitude pier. A new pier was therefore built 67.4 feet east of the longitude pier, where an unobstructed view of the meridian could be obtained. (See Pl. IV.)

A Fauth combined transit and zenith telescope (No. 534) was mounted on this pier, and in August, 1896, observations for latitude, *by the Talcott method*, were made by Mr. S. S. Gannett. Pairs of stars were selected from Safford's Catalogue of 2018 Stars. The apparent day places, however, were obtained from the Berliner Jahrbuch whenever possible; otherwise, they were computed by the usual methods, as explained in the American Ephemeris.

Fifty-nine observations upon twenty-seven pairs of stars gave a weighted mean value for the latitude of the pier of 47° 39′ 51″.46 ± 0″.13. The results for different nights and for different pairs of stars are given in the following table:

Results for latitude, Spokane (Washington) Station, 1896.

[S. S. Gannett, observer and computer.]

Stars (Safford), number and class.	Individual results. 47° 39′.				Mean.	Weight.
	Aug. 6.	Aug. 7.	Aug. 8.	Aug. 9.		
	Seconds.	*Seconds.*	*Seconds.*	*Seconds.*	*Seconds.*	
748 A, 759 A	....	....	51.54	50.17	50.85	1.72
766 A, 782 C	....	50.05	....	53.27	51.66	1.28
772 A, 782 C	....	....	....	51.46	51.46	0.79
795 C, 801 AA	....	51.69	50.70	50.66	51.02	1.69
809 C, 852 A	....	50.04	50.92	49.01	49.99	1.62
814 A, 852 A	....	50.16	49.68	49.80	49.88	2.40
814 A, 856 AA	....	50.90	49.57	....	50.24	1.80
809 C, 856 AA	....	50.78	50.80	....	50.79	1.32
809 C, 834 AA	....	....	....	49.81	49.81	0.80
814 A, 834 AA	....	....	....	50.58	50.58	0.96
882 AA, 917 C	....	....	52.08	....	52.08	0.80
901 C, 903 AA	....	....	....	51.05	51.05	0.80
903 AA, 920 C	....	....	....	50.65	50.65	0.80
931 B, 949 A	....	52.56	....	49.71	51.13	1.63
957 A, 969 A	....	52.15	....	51.30	51.67	1.72
987 •A, 989 B	53.81	53.58	53.12	52.52	53.26	2.70
989 B, 1000 AA	52.46	52.90	52.38	51.74	52.37	2.90
1011 B, 1032 B	....	....	....	51.57	51.57	0.88
1016 B, 1032 B	52.10	....	51.57	52.66	52.11	2.05
1032 B, 1037 B	51.62	51.36	51.78	51.20	51.49	2.47
1032 B, 1047 C	....	51.58	52.02	50.15	51.25	1.53
1059 A. 1078 A	52.82	51.59	51.75	49.14	51.32	2.99
1188 AA, 1129 A	....	52.21	51.37	51.07	51.16	2.55
1129 A, 1146 B	....	53.54	53.37	....	53.45	1.63
1133 AA, 1158 A	....	....	....	52.63	52.63	0.96
1161 A, 1173 C	....	....	50.30	....	50.30	0.79
1202 AA, 1207 A	....	53.06	53.00	....	53.03	1.80

Weighted mean, 47° 39′ 51″.46 ± 0″.13.

LONGITUDE.

The meridional portion of the line is defined as corresponding to the thirty-ninth degree of longitude west from Washington.

Section 435, Revised Statutes, provides that "The meridian of the Observatory at Washington shall be adopted and used as the American meridian for all astronomical purposes," and this has been construed as meaning the old Naval Observatory. The latest adjustment by the United States Coast and Geodetic Survey fixes the longitude of the center of the dome of the United States Naval Observatory (old site) at $5^h\ 08^m\ 12^s.153 \pm 0^s.049$, or $77^\circ\ 03'\ 02''.30 \pm 0''.74$; hence the longitude of the meridian corresponding to the boundary line between Idaho and Montana is $116^\circ\ 03'\ 02''.30$.

The United States Coast and Geodetic Survey has published an adjusted network of telegraphic longitude determinations, including points distributed in various localities throughout the United States. This system includes the Naval Observatory at Washington and also a station at Helena, Montana. From Helena the Coast Survey in 1888 determined the longitude of a pier in the court-house grounds at Spokane.

The nightly programme at each station was to observe, with an astronomic transit, two sets of ten stars each for local time, each half set consisting of four stars having a mean azimuth factor nearly equal to zero, and one circumpolar star. Two such half sets, with a reversal of the telescope in the Y's between them, give a strong time determination. The same sets of stars were observed at Helena and at Spokane, thus giving the chronometer error for each local meridian.

Between the two time sets the chronometers were compared by telegraph, thus giving the difference in time, and consequently in longitude, between the meridians within a small fraction of a second. As will be noticed in the following table, such observations and chronometer comparisons were made on four nights, when the observers interchanged places and made similar observations and chronometer comparison on four other nights, thus eliminating the effect of "personal equation."

The figures relating to this description, which were kindly furnished by the Superintendent of the United States Coast and Geodetic Survey, are presented below:

Resulting difference of longitude between the astronomic stations at Spokane, Washington, and Helena, Montana, as determined by the United States Coast and Geodetic Survey in September, 1888.

Date.	Observer.		From western or Spokane signals.	From eastern or Helena signals.	W. E.	Mean of west and east signals.	Correction for personal equation.	Difference of longitude. Δ λ	Combination weight.	Difference. ν
	Spokane.	Helena.								
1888.			′ ″	′ ″	°	′ ″	″	′ ″		″
Sept. 13....	R. A. Marr.	C.H. Sinclair.	21 34.193	21 34.171	0.022	21 34.182	+0.208	21 34.390	6	+0.047
Sept. 15....			.218	.164	.054	.191	....	.399	5	+ .038
Sept. 22....			.299	.247	.052	.273	....	.481	5	− .044
Sept. 24....			.283	.224	.059	.254	....	.462	10	− .025
				Mean...	.047	21 34.225				
Sept. 26....	C.H. Sinclair.	R. A. Marr.	21 34.616	21 34.591	0.025	21 34.604	−0.208	.396	4	+ .041
Sept. 27....			.702	.673	.029	.687	....	.479	4	− .042
Sept. 28....			.667	.625	.042	.646	....	.438	5	− .001
Sept. 29....			.663	.619	.044	.641	....	.433	5	+ .004
				Mean...	.035	21 34.644	....	21 34.435		
					Weighted mean......			21 34.437		± .009

Transmission time, $0^s.020 \pm 0^s.002$.

Personal equation, Marr-Sinclair, $0^s.208 \pm 0^s.009$.

At Spokane, transit No. 19 was mounted in the grounds of the county court-house.

At Helena, transit No. 18 was mounted over the station in the northwest corner of the grounds of the United States assay office. The station was established in 1888. The court-house tower is $0^s.324$ or 4″.86 east and 0″.811 south of the transit.

$\Delta \lambda$ Spokane-Helena $= 21^m\ 34^s.437 \pm 0^s.009$.

λ Helena (transit 1888), $7^h\ 28^m\ 08^s.789 \pm 0^s.052$.

λ Spokane (transit), $7^h\ 49^m\ 43^s.228 \pm 0^s.053$.

117° 25′ 48″.39 ± 0″.80.

From the foregoing it will be observed that the probable error of the longitude determination of the Spokane pier is 0″.80, or about 54 feet. Through a connection with the pier at Spokane the longitude of the meridian of the boundary line was established by triangulation and traverse, as will appear hereafter.

It may be remarked, in connection with the foregoing, that while the meridian of the Observatory at Washington is, by law approved September 28, 1850, the American meridian for all astronomical purposes, the geodetic operations of the country generally are conducted with reference to the meridian of Greenwich as an initial point. Government maps are usually referred to Greenwich, and standard time is reckoned from it.

SPOKANE BASE LINE.

A site for this base line was found in the valley of the Spokane River, east of the city of Spokane, points for its expansion being located on the surrounding hills. The line was measured along a tangent of the Northern Pacific Railway, beginning about 2.5 miles east of the Spokane depot and extending eastward 5 miles. It was prepared by nailing boards 1 by 6 by 60 inches 300 feet apart along the cross-ties parallel to the rail. On each board a smaller board (1 by 4 by 12 inches) was nailed, and on the latter was tacked a strip of zinc 2 by 10 inches. At night two complete measurements were made with United States Geological Survey steel tape No. 1, under a tension of 20 pounds, temperature being taken by reading three thermometers at each tape length. The front end of the tape was marked on the zinc strip with a fine brad awl. The length of the tape used, compared with the mural standard of the United States Coast and Geodetic Survey on October 30, 1895, was found to be 300.0075 feet; on December 5, 1896, 300.0058 feet. The mean of these two, 300.0067 feet, was adopted.

Adopted coefficient of expansion	F	.0000065
Mean temperature of first measurement		60°.35
Mean temperature of second measurement		59°.25
Difference between the two measurements, when corrected for temperature	feet	.006
Mean elevation of the line above sea level, as given by a profile furnished by the Northern Pacific Railway	feet	1,972
Length of base corrected for temperature	do	26,407.288
Correction for inclination	do	—0.156
Reduction to sea level	do	—2.491
Reduced length	do	26,404.641
Logarithm of length, in meters		3.9056962

The terminal points were transferred to the embankment 25 feet north of north rail, and the new points being intervisible, high tripod supports for the theodolite were necessary.

AZIMUTH.

The azimuth of the Spokane base line was determined by mounting 8-inch micrometer theodolite No. 300 over the west base and measuring the angle between Polaris and a mark placed at the east base. A series of observations, consisting of eighteen pointings (direct and reverse), was taken near elongation August 15, 1896, the resulting mean for azimuth west base-east base being 253° 18′ 45″.80.

With this value and the astronomic location of the cupola of the court-house at Spokane the positions of all triangulation stations and azimuths of all lines in the main belt of triangulation eastward to Divide and Scotchman stations, near the Idaho-Montana boundary line were computed. A check azimuth was observed at Divide triangulation station July 7, 1898, with the same theodolite. Twenty pointings (direct and reversed) on Polaris were obtained and referred to Scotchman station.

	°	′	″
Azimuth of line Divide-Scotchman computed from Spokane base	170	18	05.87
Azimuth of same line by direct observation	170	18	10.25
Difference			4.38

The observed value was adopted in the computation of positions in the extension of the triangulation northward to the international boundary.

Examples of record and computation for azimuth determination are given herewith:

Azimuth determinations at triangulation station Divide, July 7, 1898. S. S. Gannett, observer.

[Latitude (φ) 47° 57′ 57″.51. Longitude (λ) 116° 01′ 33″.08]

	Time.	Level.		Micrometer A.	Micrometer B.	Mean.	Angle.
		W.	E.				
	h. m. s.	*d.*	*d.*	° ′ *d.*	° ′ *d.*	° ′ ″	° ′ ″
Azimuth mark		13.0	16.0	221 09 02	41 09 13	221 09 15	
Polaris D	10 27 52	11.8	18.0	255 33 24	75 34 07	255 34 01	34 24 46
		24.8	34.0				
		−9.2					
Polaris R	10 33 48	13.8	15.3	75 36 08	255 34 21	75 35 29	
Azimuth mark		14.0	15.0	41 09 18	221 08 11	41 08 59	34 26 30
		27.8	30.3				
		−2.5					
Azimuth mark		14.0	11.5	78 10 23	258 09 09	78 10 02	
Polaris R	10 42 02	13.5	12.0	112 39 14	292 38 08	112 38 52	34 28 50
		27.5	23.5				
		+4.0					
Polaris R	10 46 08	16.0	16.0	292 40 02	112 40 11	292 40 13	
Azimuth mark		18.2	14.0	258 09 28	78 10 14	258 10 12	34 30 01
		34.2	30.0				
		+4.0					

Time by mean time watch, 34 seconds fast on one hundred and fifth meridian time.

One division of striding level = 3″.66; 1 division of micrometer = 2″.00.

Level correction $= -\frac{d}{4}\left\{(w+w')-(e+e')\right\}\tan h$; d being the value of a division of the level, $w+w'$ readings of west end of level bubble, $e+e'$ readings of east end of level bubble, and h, the angular elevation of star, the foregoing formula reduces as follows:

$$\frac{3''.66}{4}\times\tan 47° 57' 57''\ (1.11) = 1''.01.$$

The formula for reduction of azimuth observations at any hour angle is $\tan A = -\frac{a \sin t}{1-b \cos t}$, where $a=\sec \phi \cot \delta$, $b=\tan \phi \cot \delta$.

$\log \sec \phi$, 47° 57′ 57″ $=0.17421$	$\log \tan \phi=0.04505$
$\log \cot \delta$, 88 45 46 $=8.33439$	$\log \cot \delta=8.33439$
$\log a$ $=8.50860$	$\log b$ $=8.37944$

	m.	s.
Watch correction	=− 0	34
Longitude correction	=−44	06
Total correction	=−44	40

	Computation of first observation.	Computation of second observation.	Computation of third observation.	Computation of fourth observation.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.
Watch time of observation	10 27 52	10 33 48	10 42 02	10 46 08
Reduction to local meridian	−44 40	−44 40	−44 40	−44 40
Local mean time	9 43 12	9 49 08	9 57 22	10 01 28
Correction to sidereal	+1 36	+1 37	+1 38	+1 39
α of sun	7 03 11	7 03 11	7 03 11	7 03 11
Sidereal interval	16 47 59	16 53 56	17 02 11	17 06 18
α of Polaris	−1 21 51	−1 21 51	−1 21 51	−1 21 51
t	15 26 08	15 32 05	15 40 20	15 44 27
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
t in arc	231 32 00	233 01 15	235 05 00	236 06 45
Log cos t	9.79383	9.77925	9.75769	9.74630
Log b	8.37944	8.37944	8.37944	8.37944
Log b cos t	8.17327	8.15869	8.13713	8.12574
b cos t	.01490	.01441	.01371	.01336
1−b cos t	1.01490	1.01441	1.01371	1.01336
Log sin t	9.89375	9.90246	9.91381	9.91915
Log a	8.50860	8.50860	8.50860	8.50860
Log a sin t	8.40235	8.41106	8.42241	8.42775
Log (1−b cos t)	0.00642	0.00621	0.00591	0.00575
Log tan A	8.39593	8.40485	8.41650	8.42200
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
Azimuth of star	181 25 32	181 27 18	181 29 41	181 30 49
Angle to mark	−34 24 46	−34 26 30	−34 28 50	−34 30 01
Level correction	+9	+2	−4	−4
Azimuth of mark	147 00 55	147 00 50	147 00 47	147 00 44

The mean of twenty observations reduced in a similar manner = 147° 00′ 51″.15.

Check azimuths along the random line were measured with Young transit No. 6838. The instrument was usually set over one stadia station and a mark placed on another station. Six measurements (three direct and three reversed) of angle between Polaris and mark were then made. These observations were reduced at once by the method and tables given in the Manual of Surveying Instructions issued by the General Land Office, 1894, pages 109–119. An example of record and computation follows.

[July 19, 1898. Stadia ⊡ 77. D. L. Reaburn, observer.]

TELESCOPE DIRECT.

	Time.	A.	B.	Mean.	Angle.
	h. m. s.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
Azimuth mark	....	0 03 30	180 03 30	0 03 30	....
Polaris	9 03 40	1 19 00	1 18 30	1 18 45	1 15 15

TELESCOPE REVERSED.

Polaris	9 15 18	180 23 00	0 22 30	180 22 45	....
Azimuth mark	....	180 02 30	180 02 30	0 02 30	1 20 15

TELESCOPE REVERSED.

Azimuth mark	....	35 14 00	215 14 00	35 14 00	....
Polaris	9 30 00	36 38 30	216 38 30	36 38 30	1 24 30

TELESCOPE DIRECT.

Polaris	9 33 30	36 40 00	216 40 00	36 40 00	....
Azimuth mark	....	35 14 00	215 14 00	35 14 00	1 26 00

TELESCOPE DIRECT.

Azimuth mark	....	81 12 00	261 12 00	81 12 00	....
Polaris	9 39 45	82 39 00	262 39 00	82 39 00	1 27 00

TELESCOPE REVERSED.

Polaris	9 41 45	82 41 00	262 40 30	262 40 45	....
Azimuth mark	....	81 12 00	261 11 30	81 11 45	1 29 00

[July 19, 1898. Stadia ⊡ 77. Latitude 48° 03′; longitude 116° 03′. Watch fast $42^m 36^s$ on local time.]

	H. M.
Upper culmination Polaris, July 15	17 43.5
Reduction to July 18	−11.8
Upper culmination July 18, being culmination preceding time of observation on July 19	=17 31.7

[D. L. Reaburn, computer.]

	Computation of first observation.	Computation of second observation.	Computation of third observation.	Computation of fourth observation.	Computation of fifth observation.	Computation of sixth observation.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
Time of observation	9 08.7	9 15.3	9 30.0	9 33.5	9 39.7	9 41.7
Watch correction	−42.6	−42.6	−42.6	−42.6	−42.6	−42.6
Local mean time	8 21.1	8 32.7	8 47.4	8 50.9	8 57.1	8 59.1
	+24	+24	+24	+24	+24	+24
	32 21.1	32 32.7	32 47.4	32 50.9	32 57.1	32 59.1
Subtract up. culmination	−17 31.7	17 31.7	17 31.7	17 31.7	17 31.7	17 31.7
Hour angle	14 49.4	15 01.0	15 15.7	15 19.2	15 25.4	15 27.4
Subtract from	23 56.1	23 56.1	23 56.1	23 56.1	23 56.1	23 56.1
Time argument	9 06.7	8 55.1	8 40.4	8 36.9	8 30,7	8 28.7
Azimuth Polaris—	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
At observation	181 13 45	181 18 30	181 23 12	181 24 16	181 26 00	181 27 00
Angle to mark	1 15 15	1 20 15	1 24 30	1 26 00	1 27 00	1 29 00
Azimuth of mark	179 58 30	179 58 15	179 58 42	179 58 16	179 59 00	179 58 00

Mean = 179° 58′ 33″ showing this portion of the random line to deviate from the true meridian by 1′ 27″.

TRIANGULATION.

The triangulation connecting the Spokane base with the boundary line was done with an 8-inch micrometer theodolite, reading by two micrometers to two seconds and by estimation to one second. Directions were read in sets, each set consisting of pointings with telescope direct and reversed from left to right and from right to left. Four or more of such sets were usually taken. A few secondary locations on or near the boundary line were made with the transit. All of the observations were reduced in the office by least squares.

The following list gives descriptions, latitude, longitude, azimuths, and distances of the triangulation stations determined which have a bearing on the boundary line.

A diagram of the triangulation is also presented. (See Pl. V.)

SPOKANE, EAST BASE.

Station mark: A dressed stone, 7 by 7 by 36 inches, set 30 inches in ground, 25 feet north of north rail, and 94 feet eastward from sign marked "Trent 1 mile." The stone is marked on top
"U. S.
+
E. Base."

[Latitude, 47° 41′ 01″.94. Longitude, 117° 16′ 00″.81.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Moran	14 37 16.02	194 35 48.17	3.9929426
West base	73 23 19.07	253 18 45.80	3.9056962
Court-house cupola	80 02 46.43	259 55 31.41	4.0956581
Little Baldy	117 19 24.54	297 16 30.04	3.7432302
Skalan	288 10 38.61	108 22 55.95	4.3409600

SPOKANE, WEST BASE.

Station mark: A dressed stone, 7 by 7 by 36 inches, set 30 inches in the ground, 25 feet of north rail and 218 feet eastward from signboard, "R. R. X'ng ½ mile." Top of the stone is marked

"U. S.
+
W. Base."

[Latitude, 47° 39′ 47″.28. Longitude, 117° 22′ 10″.45.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Court-house cupola	91 45 38.07	271 42 56.36	3.6595819
Tomkinson	137 10 30.83	317 06 36.14	3.9881446
Little Baldy	209 54 21.35	29 56 00.21	3.7474231
East base	253 18 45.80	73 23 19.07	3.9056962
Skalan	278 57 36.00	99 14 26.34	4.4609400
Moran	324 00 35.75	144 03 41.01	3.9500715

COURT-HOUSE CUPOLA, SPOKANE.

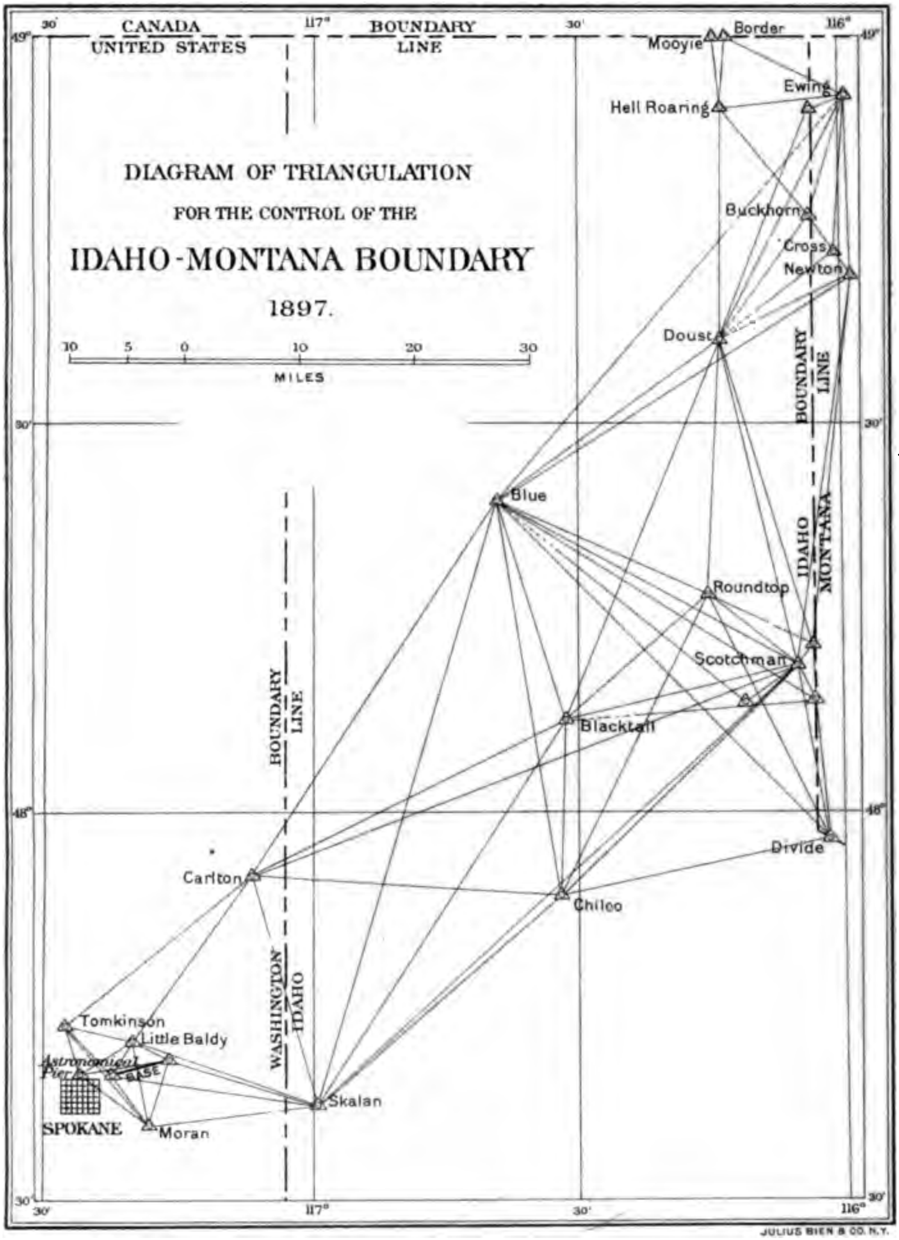
(Not occupied.)

This point is connected, by direct measurement, with longitude pier of the United States Coast and Geodetic Survey of 1888 and with latitude pier of the United States Geological Survey of 1896. It is also connected, by triangulation, with the stations of the base expansion. The point located is the center of the flagstaff, which is over the center of the cupola of the new court-house.

Latitude, 47° 39′ 51″.76. Longitude, 117° 25′ 49″.21.

MORAN, SPOKANE COUNTY.

Location of station: On the northern end of a high, wooded ridge, about 8 miles southeast of Spokane, in a cleared field about 50 feet [illegible] of the ruins of a log cabin. A wagon road runs to the station.



JULIUS BIEN & CO. N.Y.

Station mark: A dressed stone, 8 by 8 by 36 inches, set 30 inches in the ground, marked "U. S. △."

[Latitude, 47° 35′ 53″.67. Longitude, 117° 17′ 59″.70.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Court-house cupola	126 55 28.15	306 49 41.22	4.0882682
Tomkinson	140 29 39.00	320 22 39.05	4.2697837
Little Baldy	168 33 40.57	348 32 14.04	4.0900766
Skalan	263 25 05.73	83 38 50.36	4.3704936

LITTLE BALDY, SPOKANE COUNTY.

Location of station: On a small flat-topped hill 5 miles northeast of Spokane, and in the center of a cleared field on the highest part of hill. A fringe of tall pine trees extends around the hill.

Station mark: A dressed stone, 8 by 8 by 36 inches, set 30 inches in the ground, marked "U. S. △."

[Latitude, 47° 42′ 24″.16. Longitude, 117° 19′ 56″.74.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Court-house cupola	57 24 18.29	237 19 57.66	3.9409362
Tomkinson	103 43 22.18	283 37 48.45	3.9857308
Mount Carlton	214 13 32.20	34 23 09.80	4.4590100
Skalan	289 58 08.50	110 13 20.40	4.4378494
East base	297 16 30.04	117 19 24.54	3.7432302

TOMKINSON, SPOKANE COUNTY.

Location of station: On the southern part of a small table-land 4 miles north of Spokane, on the highest knoll in pasture of Mr. Tomkinson and one-eighth of a mile southwest of his house.

Station mark: A dressed stone, 8 by 8 by 36 inches, set 30 inches in the ground, marked "U. S. △."

[Latitude, 47° 43′ 38″.24. Longitude, 117° 27′ 27″.85.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Carlton	229 52 16.64	50 07 28.61	4.5239434
Court-house cupola	343 36 09.45	163 37 22.41	3.8627730

SKALAN, KOOTENAI COUNTY, IDAHO.

Location of station: Twenty miles east of Spokane, Washington, and 3 miles east of Washington-Idaho boundary line. The summit is a bald, rocky ridge, and can be reached by a good trail from Dr. Dennison's ranch, on the east side of Skalan Creek.

Station mark: A copper bolt set in solid rock, above which is a cairn 5 feet in diameter at base and 5 feet in height.

[Latitude, 47° 37′ 19″.26. Longitude, 116° 59′ 23″.15.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Moran	83 38 50.36	263 25 05.73	4.3704936
Little Baldy	110 13 20.40	289 58 08.50	4.4378494
Carlton	164 08 34.00	344 02 57.76	4.5378730
Blacktail	212 17 12.70	32 38 06.17	4.8158528
Chilco	228 45 58.75	49 06 20.29	4.6587750

CARLTON, SPOKANE COUNTY, WASHINGTON.

Location of station: About 35 miles by road and trail northeast of Spokane, Washington. The mountain has two summits of nearly equal height and about one-third of a mile apart. The station is on the southern summit, which is flat and bald, but has a growth of pine and spruce trees on its western side. There is a good trail to station from The Meadows.

Station mark: A copper bolt set in solid rock, above which is a rock cairn 5 feet in diameter and 5 feet in height.

[Latitude, 47° 55′ 13″.71. Longitude, 117° 06′ 57″.26.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Little Baldy	34 23 09.49	214 13 31.91	4.4589864
Tomkinson	50 07 28.61	229 52 16.64	4.5239434
Blacktail	243 24 10.03	63 50 44.00	4.6954456
Chilco	274 01 32.58	94 27 33.97	4.6416575
Skalan	344 02 57.76	164 08 34.00	4.5378730

BLACKTAIL, KOOTENAI COUNTY, IDAHO.

Location of station: On a bald point near the south end of summit, near the western shore of Lake Pend Oreille and east of Cocolalla, on

Northern Pacific Railway. It can be easily reached by trail from T. Trumbull's ranch.

Station mark: A copper bolt sunk in solid rock, above which is a cairn 5 feet in diameter and 5 feet in height.

[Latitude, 48° 07′ 07″.09. Longitude, 116° 31′ 13″.03.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Chilco	1 53 09.56	181 52 39.78	4.4029303
Skalan	32 38 06.17	212 17 12.70	4.8158528
Carlton	63 50 44.00	243 24 10.63	4.6954456
Round Top	228 10 27.76	48 22 33.96	4.4305996
Scotchman	256 22 33.71	76 42 07.01	4.5246835

CHILCO, KOOTENAI COUNTY, IDAHO.

Location of station: On the south end of grassy summit south of the steamboat landing on Lake Pend Oreille. It can be easily reached from Collins's ranch by Leiberg trail.

Station mark: A copper bolt sunk in solid rock, above which is a rock cairn 5 feet in diameter at base and 5 feet in height.

[Latitude, 47° 58′ 28″.75. Longitude, 116° 31′ 53″.09.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Skalan	49 06 20.29	228 45 58.75	4.6587752
Carlton	94 27 33.97	274 01 32.58	4.6416575
Blacktail	181 52 39.78	1 53 09.56	4.4029303
Round Top	205 48 07.02	26 00 41.75	4.6816159
Scotchman	225 10 00.98	45 30 01.97	4.6724527
Divide	257 25 15.62	77 47 46.64	4.5875062

SCOTCHMAN, KOOTENAI COUNTY, IDAHO.

Location of station: On the southwestern of three summits, about a mile west of the Idaho-Montana boundary line and 6 miles northeast of Clark Fork, a station on the Northern Pacific Railway. It can be reached from Lightning Creek by an old Indian trail—a roundabout way, though the easiest one.

Station mark: A copper bolt in solid rock, above which is a rock cairn 5 feet in diameter and 5 feet in height.

[Latitude, 48° 11′ 19″.36. Longitude, 116° 04′ 58″.02.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Chilco	45 30 01.97	225 10 00.98	4.6724527
Blacktail	76 42 07.01	256 22 33.71	4.5246835
Round Top	129 21 22.70	309 13 54.54	4.2047087
Divide	350 15 33.38	170 18 05.87	4.4001417

ROUND TOP, KOOTENAI COUNTY, IDAHO.

Location of station: Northeast of Hope, on the Sherry trail, near Hogeye camp, on the southern end of the summit, which extends 100 yards north and south.

Station mark: A copper bolt sunk in rock, above which is a rock cairn 5 feet in diameter and 5 feet in height.

[Latitude, 48° 16′ 47″.86. Longitude, 116° 14′ 58″.88.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Chilco	26 00 41.75	205 48 07.02	4.6816159
Blacktail	48 22 33.96	228 10 27.76	4.4305996
Scotchman	309 13 54.54	120 21 22.70	4.2047087
Divide	334 24 02.60	154 34 02.58	4.5855553

DIVIDE (1).

Location of station: On a knoll on divide of the Bitterroot Mountains on the boundary line between Idaho and Montana. It is not the highest point, but it is almost cleared of timber. Station is best reached from Heron, Montana, by the Elk Creek trail.

Station mark: A copper bolt sunk in solid rock, above which is a rock cairn 3 feet in height and 3 feet in diameter.

[Latitude, 47° 57′ 57″.51. Longitude, 116° 01′ 33″.08.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Chilco	77 47 46.64	257 25 15.62	4.5875062
Round Top	154 34 02.58	334 24 02.60	4.5855553
Scotchman	170 18 05.87	350 15 33.38	4.4001417

MOOYIE TRAIL MONUMENT.

On or near the boundary line between Kootenai County, Idaho, and *British Columbia*, about 32 miles northward from Bonners Ferry.

Easily reached by the new Wild Horse trail, 5 miles from Round Meadows or Prairie. Monument is about a half mile beyond a portion of trail filled with loose rocks, and just beyond a heavy growth of timber and underbrush. Where the trail crosses the international boundary there is a large tree squared about 4 feet above the ground. On the south side of the tree are cut the letters "U. S.," on the north side the letters "B. C." Monument is west of this tree.

Station mark: Copper bolt sunk in soil, over which is a monument of loose stone and a tree 20 feet in height.

[Latitude, 49° 00′ 01″.51. Longitude, 116° 14′ 19″.48.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Border	267 48 09.25	87 49 12.16	3.22930
Hell Roaring	353 09 44.78	173 10 30.25	4.01339

BLUE, KOOTENAI COUNTY, IDAHO.

Location of station: On southeasternmost of three summits of nearly equal height, 5½ miles west of Sand Point, on Great Northern Railway, 7 miles west of Sand Point, on Northern Pacific Railway; eight hours' travel from Carr's ranch, on Rider Creek, passing "Old Baldy," thence along ridge.

Station mark: Copper bolt in solid rock, over which is a rock cairn 5 feet in height.

[Latitude, 48° 24′ 01″.52. Longitude, 116° 38′ 55.″78.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Doust	232 53 14.44	53 12 26.21	4.5965347
Newton	236 01 09.17	56 31 23.44	4.7758946
Scotchman	299 03 30.80	119 28 52.14	4.6825857
Blacktail	343 00 37.10	163 06 22.39	4.5152727

DOUST, KOOTENAI COUNTY, IDAHO.

Location of station: About 7 miles southeast from Bonners Ferry. Best reached from Wright's ranch, in Paradise Valley. Follow trail leading to mineral claims of Doust & Wright to summit of Wright Mountain, thence along ridge over fallen timber to station; three hours' travel.

Station mark: Copper bolt in solid rock, above which is a rock cairn 5 feet in height.

[Latitude, 48° 36′ 50″.16. Longitude, 116° 13′ 18″.15.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Blacktail	21 59 49.24	201 46 25.83	4.7734417
Blue	53 12 26.21	232 53 14.44	4.5965347
Hell Roaring	179 57 47.07	359 57 46.29	4.5150730
Ewing	206 31 13.33	26 41 59.63	4.5929986
Cross	232 19 53.73	52 29 34.08	4.3000641
Newton	242 25 12.51	62 36 15.35	4.3089562
Scotchman	347 40 26.39	167 46 40.40	4.6847536

HELL ROARING, KOOTENAI COUNTY, IDAHO.

Location of station: On southern end of the eastern of two round peaks at the head of Hell Roaring Creek. From Round Prairie a trail runs south of Hell Roaring Creek to summit of mountain.

Station mark: Copper bolt in solid rock, above which is a rock cairn 4½ feet high.

[Latitude, 48° 54′ 30″.02. Longitude, 116° 13′ 19″.18.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mooyie Trail monument	173 10 30.25	353 09 44.78	4.01339
Border	182 36 16.26	2 36 33.65	4.01348
Ewing	262 28 39.26	82 39 27.78	4.2471106
Cross	322 24 20.27	142 34 02.70	4.4137728
Doust	359 57 46.29	179 57 47.07	4.5150730

SCOTCHMAN (2), KOOTENAI COUNTY, IDAHO.

A secondary station near boundary post No. 72, at summit of Cabinet Mountain, occupied with transit.

[Latitude, 48° 12′ 50″.40. Longitude, 116° 03′ 14″.98.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Scotchman	37 07 25	217 06 08	3.54730
Divide	355 37 01	175 38 16	4.44183
Transit station 154	357 34 30	177 34 42	3.87099

BUCKHORN, KOOTENAI COUNTY, IDAHO.

A secondary station near boundary post No. 23, at summit of Yak Mountain, occupied with transit.

[Latitude, 48° 46′ 22″.57. Longitude, 116° 03′ 16″.03.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Doust	34 55 05.20	214 47 32.90	4.33338
Transit station 949	181 09 14.60	1 09 25.90	4.18013
Newton	325 15 17.30	145 18 48.30	4.00320
Ewing	196 47 42.90	16 51 04.97	4.25810
Cross	327 38 03.50	147 40 20.26	3.81428

BLACKTOP, KOOTENAI COUNTY, IDAHO.

A secondary station near boundary post No. 74. Reached from Clark Fork, Idaho, by trail to Homestake cabin; thence to divide between Blue and Mosquito creeks; then by four hours' travel (on foot) to station, following along slope of mountain.

Station mark: Cross cut on solid rock, under a rock monument 3 feet in height.

[Latitude, 48° 11′ 50″.72. Longitude, 116° 03′ 49″.28.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Scotchman	55 42 20	235 41 29	3.23516
Transit station 154	349 37 02	169 37 39	3.75359

NEWTON, FLATHEAD COUNTY, MONTANA.

Location of station: On second summit southeast of Newton Pass, on trail from Newton's ranch to Sylvanite.

Station mark: Iron bolt in solid rock, above which is a rock cairn 5 feet in height.

[Latitude, 48° 41′ 54″.51. Longitude, 115° 58′ 35″.26.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Scotchman	7 56 25.44	187 51 39.02	4.7576096
Blue	56 31 23.44	236.01 09.17	4.7758946
Doust	62 36 15.35	242 25 12.51	4.3089562
Cross	140 57 32.97	320 56 10.32	3.5525754
Ewing	178 55 40.21	358 55 22.48	4.4087123

EWING, FLATHEAD COUNTY, MONTANA.

Location of station: In extreme northwestern corner of State, about 35 miles northeast of Bonners Ferry, Idaho. It can be reached by trail to Buckhorn mines, thence along divide 4 miles to break-off, thence northeast down into the basin or meadows, thence ascending ridge in northwest direction, thence along ridge to summit.

Station mark: Copper bolt in loose rock, above which is cairn of rocks 4½ feet high.

[Latitude, 48° 55′ 43″.99. Longitude, 115° 58′ 58″.82.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Cross	4 25 15.00	184 24 09.92	4.3602056
Buckhorn	16 51 04.97	196 47 42.90	4.2581050
Doust	26 41 59.63	206 31 13.33	4.5929986
Transit station 949	65 56 28.90	245 53 26.30	3.7325500
Hell Roaring	82 39 27.78	262 28 39.26	4.2471106
Border	115 18 08.80	295 07 37.22	4.2747300
Newton	358 55 22.48	178 55 40.21	4.4087124

CROSS, FLATHEAD COUNTY, MONTANA.

Location of station: On first summit northwest of Newton Pass, on trail between Sylvanite and Newton's ranch.

Station mark: Copper bolt in loose rocks, above which is cairn of rocks 4½ feet high.

[Latitude, 48° 43′ 24″.24. Longitude, 116° 00′ 25″.26.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Doust	52 29 34.08	232 19 53.73	4.3000841
Hell Roaring	142 34 02.70	322 24 20.27	4.4137728
Buckhorn	147 40 20.26	327 38 03.50	3.8142800
Ewing	184 24 09.92	4 25 15.00	4.3602056
Newton	320 56 10.32	140 57 32.97	3.5525754

BORDER, IN CANADA.

Location of station: Just north of Kootenai County, Idaho. Reached from the Mooyie Trail by a trail to Grierson's ranch; thence by Indian *trail to small* lake lying to the east; thence around lake to ridge; *thence up ridge* to station.

Station mark: Copper bolt in solid rock, above which is a rock cairn 4½ feet high.

[Latitude, 49° 00′ 03″.60. Longitude, 116° 12′ 56″.12.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hell Roaring	2 36 33.65	182 36 16.26	4.01348
Mooyie	87 49 12.16	267 48 09.25	3.22930
Ewing	295 07 37.22	115 18 08.80	4.27473

TRANSIT STATION 154.

A secondary station near boundary post No. 78; best reached by trail from Clark Fork, Idaho, by way of the Homestake cabin, to Blue Creek; two hours' travel to cabin, one and one-half hours from cabin to camp on Blue Creek. The ridge leading from Blue Creek to the station can be ascended on the south side in one and one-half hours.

Station mark: Copper bolt in rock, over which is a rock cairn 3 feet in height.

[Latitude, 48° 08′ 50″.14. Longitude, 116° 02′ 59″.84.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Blacktail	84 58 53	264 37 52	4.54599
Scotchman	152 05 45	332 04 17	3.71732
Scotchman (2)	177 34 42	357 34 30	3.87099
Divide	354 53 39	174 54 44	4.30621

TRANSIT STATION 949, NEAR IDAHO-MONTANA BOUNDARY LINE.

A secondary station on a large hill near boundary post No. 9, 6½ miles south of international boundary.

Station mark: None.

Reference mark: Signal tree, distant 138 feet, azimuth to which is 308° 55′.

[Latitude, 48° 54′ 32″.59. Longitude, 116° 03′ 01″.05.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Buckhorr	1 09 25.9	181 09 14.6	4.18013
Doust	21 04 23.9	200 56 39.8	4.54598
Ewing	245 53 26.3	65 56 28.9	3.73255

DIVIDE (2).

This triangulation station is not on the meridional portion of the line, but on the crest of the Bitterroot Mountains, farther south, and was located in connection with the survey of the Bitterroot Forest Reserve.

It is on the main summit of the Bitterroot Range, on the boundary line between Montana and Idaho, 20 miles (air line) west of Grantsdale. It can be reached from the Lost Horse Pass (camp being at Twin Lakes) by following the northwest face of the mountain northeast from the Twin Lakes to the crossing of Moose Creek, thence up the creek to the Meadows. The peak lies to the northwest, about 2,000 feet above the meadow.

Station mark: A rock cairn 5 feet in diameter and 8 feet in length.

[Latitude, 46° 11′ 32″.1. Longitude, 114° 28′ 12″.2.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Ward (2)	279 32 28	99 40 31	4.16360
El Capitan	344 06 39	164 09 53	4.32652

TRANSIT AND STADIA WORK.

The transit used was one manufactured by Young & Sons, of the type known as No. 10 mountain transit, the maker's number being 6838. The horizontal circle was 4¾ inches, and this circle, as well as the vertical circle, was graduated to read with verniers to 1′. The instrument was provided with a compass attachment, fixed stadia wires, and a tripod with extension legs. The extension legs were at times very necessary, as may be seen from Pl. VI. Two stadia rods, of seasoned white pine, three-fourths inch in thickness, 12 feet in length, and 4 inches across the faces, were made in Spokane. The lower portions of the rods were tapered to a point and shod with steel. The design of the rod was black on a white ground. (See fig. 1.) By a series of tests the stadia interval was found to be in the ratio of 1 foot on the rod to 100 feet horizontal distance, as nearly as could be determined, and the rods were graduated to even feet and tenths. The extreme divisions of the rods included 10 feet, and each tenth was divided into five parts, so that hundredths could be easily read by estimation. No numbers were placed on the rods. In practice the rods were held vertically, proper corrections being applied for reducing all sights to the horizontal.

There was no expectation of obtaining exact independent results for distances measured with the transit and stadia upon the basis of the *stadia wires in the* transit being set in the ratio of 1 to 100 and the

TRANSIT STATION ON RANDOM LINE.

rods being divided so as to read to hundredths. In point of fact, probably neither of these conditions existed, even when the instrument was fresh from the hands of the maker and when the rods were newly graduated at Spokane, and much less likely is it that they existed when the instrument was subject to rough field usage and the rods were used under entirely different and variable circumstances. It was believed, however, that they could be relied upon in determining intermediate distances between points the exact distances between which were known, and so long as the ratio between the wire interval and the graduated portions of the rods remained nearly constant the purpose intended to be subserved would be accomplished. Thus, when a line was run with the stadia between two points whose positions were rigidly fixed by triangulation and the resulting error was proportionately distributed, sufficiently accurate results were obtained, much more nearly accurate than could have been obtained by chaining, especially after certain corrections had been applied.

The method used in running the random line was as follows:

The line started from an astronomic azimuth, the initial point being on a high ridge and marked with a large signal. This signal was, when possible, used as a backsight, the instrument being transited in the direct and reversed position and the mean of the two points determined for the foresight being adopted. Of course in a timbered country it was generally not possible to see the backsights for any great distance, but whenever a ridge was crossed the trees were cut out (see Pls. IX and X) and a new backsight was established. In addition, frequent observations for astronomical azimuth were made, and thus additional checks were obtained. If any considerable discrepancy was discovered between the astronomical azimuth and the instrumental line, the latter was rerun in order to obtain a satisfactory check. Further, the line was connected with the triangulation and accurately adjusted thereto in azimuth as well as in distance. When the line was adjusted to the triangulation it was apparent that the transit man had introduced into his work a decided personal equation, which had the effect of constantly swinging his line in azimuth too far to the westward, as will appear hereafter. The stadia distances were read from both backsights and foresights, so that the length of each sight was obtained in duplicate, one distance depending on rod No. 1 and the other on rod No. 2, the mean being adopted. In the same

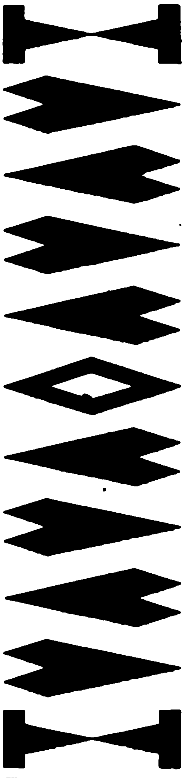


FIG. 1.—Design for stadia rod.

way vertical angles were checked by reading backsights and foresights; and thus levels were carried over the whole line. The height of the instrument above the ground station was determined at each point, and a corresponding height was sighted on the stadia rods. This height was obtained by having one of the legs of the tripod marked to tenths of a foot and by using the plumb bob as a measuring line.

The magnetic declination was read at each transit station.

The stadia line was divided into four sections:

First section. This section extended from the zero of the random line, namely, the summit of the Bitterroot Mountains, to transit station 154, and was controlled by connection with the triangulation system at both terminal points. At the summit of the Bitterroot Mountains it was connected by traverse with the triangulation station Divide, and transit station 154 was located directly by triangulation. The distance determined by stadia was 62,071 feet, and by triangulation 62,276 feet, the discrepancy being 205 feet, or 1 in 304. The azimuth correction in this section was found to be 0° 0′ 33″, corresponding to a swing of 10 feet to the east in the random line at station 154 in order to make it a true meridian line.

Second section. This section was included between stations 154 and 800. Station 800 was connected by a short traverse with the triangulation station Buckhorn. The distances determined by stadia and triangulation were, respectively, 228,014 and 228,734 feet, the difference being 720 feet, or 1 in 318. The azimuth swing at station 800 was 71 feet to the east, corresponding to an angular correction of 0° 01′ 04″.

Third section. This section was between stations 800 and 949. Station 949 was located directly by triangulation. The distance by stadia was 49,132 feet and by triangulation 49,190 feet, the difference being 58 feet, or 1 in 848. The swing in azimuth at station 949 amounted to 12.5 feet to the east, corresponding to an angular correction of 0° 0′ 52″.4.

The positions of transit stations 0, 154, 800, 949, and 1046 correspond approximately to those of monuments 92, 78, 23, 8, and 0, respectively.

Fourth section. This section closed on the international boundary, and it was unfortunate that a location by triangulation could not be obtained near its terminus, but the nature of the country rendered such a location impracticable, there being no elevated points near by and the timber being very tall and dense. It was therefore checked by careful steel-tape measurements, the tape being held horizontally under a constant tension of about 15 pounds, a plumb bob being used at each end. This section extended between station 949 and a point 45 feet north of station 1046. The distance by stadia was 33,103 feet and by steel-tape measurement 33,219 feet, the discrepancy being 116 feet, or 1 in 286.

It is proper to add that there are two small corrections which should have been applied to the distance obtained and used on this section, one being that for reduction to sea level, amounting to —8 feet, and the other that for reduction on account of tape, which, after comparison with the United States Coast and Geodetic Survey standard, was found to be +12 feet. Thus, theoretically, the monument was placed 4 feet too far north, but the error, compared with that which might result from unavoidable station error, is so small that it may be considered as negligible.

It might be well to explain what is meant by "station error." It is the error which is more or less inherent in all astronomic determinations, being caused by the deviation of the plumb bob, on account of varying local attractions, from the true vertical. Its existence may be detected by direct measurements between two astronomic stations. Assuming an astronomic location to be made at *A*, a connection by triangulation with another station, *B*, and the position of *B* thus deduced from that of *A*, then if the astronomic position of *B* is determined, the discrepancy between the astronomic position and the position determined by triangulation from *A* represents the combined station error. Efforts have been made to deduce a law, based on the contour and density of adjacent land forms, which shall define the amount of attraction affecting the plumb bob which might be expected in any particular case, but nothing satisfactory has been accomplished, owing principally to the fact that it is impossible to give an accurate value to the various components which constitute the mass of any given section of the earth's crust.

The following table gives the results obtained directly from the stadia, and which were used in reducing the random line to the true line, both in distance and in azimuth. These figures do not, however, represent the degree of precision obtained by the stadia in measuring the distances, as they are unaffected by any corrections.

Table showing discrepancy between computed and measured distances, also discrepancy in azimuth.

Section.	Stations.	Computed distance.	Stadia distance.	Latitudinal discrepancy.	Discrepancy.	Longitudinal discrepancy, random line west of true line.	Discrepancy.	Mean angular error in azimuth.
		Feet.	*Feet.*	*Feet.*		*Feet.*		° ′ ″
1	0-154	62,276	62,071	205	1 in 304	10	1 in 6,228	0 0 33
2	154-800	228,734	228,014	720	1 in 318	71	1 in 3,222	0 1 04
3	800-949	49,190	49,132	58	1 in 848	12.5	1 in 3,927	0 0 53

The distances measured by the stadia should be corrected before any satisfactory comparison can be made with the computed distances for the purpose of testing the accuracy of the stadia work.

Two conditions will be considered. The first is based upon the supposition that the rods were graduated arbitrarily into regular divisions, which were sufficiently small to admit of reading distances approximately to a foot, and that the stadia wires were set at some fixed interval. The fact that the rods were actually graduated so as to be read, as nearly as might be, to feet, tenths, and hundredths, and that the wire interval was approximate in the ratio of 1 to 100, does not enter at all into the theory of this condition. In fact the rod might be graduated in any systematic manner and the wires placed at any fixed interval without affecting the results after the proper corrections had been applied. An analogous case would be one in which certain distances were measured with a chain or tape the exact length of which was not known at the time the measurement was made but which was afterwards determined and the correction applied. The tape might prove to be 99 feet in length, but this would not affect the ultimate results after proper allowance had been made. The fourth section of the boundary line furnished a means by which the relation between the distances determined by the stadia and careful measurements with a steel tape, in other words, the stadia factor, might be ascertained.

Table of comparisons of stadia and steel-tape measurements from transit station 949 (post 8) to the international boundary (post 0), section 4.

Location.	Steel tape.	Stadia.	Difference.	Discrepancy.
	Feet	*Feet.*	*Feet.*	
Station 949	0	0	0	
Post 7	4,618.6	4,601.5	17.1	1 in 270
Post 6	8,606	8,572	34	1 in 253
Post 5	13,760.5	13,698	62.5	1 in 220
Post 4	18,148.3	18,077	71.3	1 in 254
Post 3	23,596.2	23,512	84.2	1 in 280
Post 2	27,153	27,062.5	90.5	1 in 300
Post 1	31,106	31,000	106	1 in 293
Post 0	33,219	33,103	116	1 in 286

An inspection of the foregoing table will develop the fact that the ratio existing between the results from the steel-tape and the stadia measurements is fairly constant. The steel-tape measurements were carefully made with a 100-foot steel tape, under conditions approximating those under which the other portions of the line were measured independently by the stadia, except that the surface was probably not so broken and the change of elevation not so great, thus favoring the accuracy of the tape measurement. The steel tape was afterwards compared with the United States Coast and Geodetic Survey standard, and the values in the table are affected by a small correction necessary to reduce them to the standard. Thus the comparison may be considered as determining the stadia factor, or the amount by which each stadia distance should be corrected in order to reduce it to a true measurement.

It appears from the table that in a distance of 33,219 feet the stadia measurement was 33,103 feet, or a difference of 116 feet, which corresponds to 1 in 286; this correction to be added to the stadia results.

It might be argued that it would be preferable to obtain the stadia factor by direct comparison with the computed lengths of the lines in sections 1, 2, and 3; and so it would if the rods were to be used for other purposes, but for the present purpose, which is to make a comparison between the computed distances and the direct stadia measurements, the other method is adopted.

Table showing discrepancies between stadia distances corrected for stadia factor and computed distances.

Section.	Stations.	Stadia distance reduced to mean sea level.	Correction for stadia factor, 1 in 286.	Corrected stadia distance.	Computed distance.	Discrepancy; add to stadia distance.	Discrepancy.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
1	0-154	62,061	+217	62,278	62,276	− 2	1 in 31,139
2	154-800	227,967	+797	228,764	228,734	− 30	1 in 7,625
3	800-949	49,119	+172	49,291	49,190	−101	1 in 488

A combination of the figures in the foregoing table indicates that in a total distance of 340,200 feet, or about 65 miles, there was an apparent error of 133 feet, or 1 in about 2,565. It would not, of course, be proper to claim any such accuracy for the stadia work, and in fact the figures themselves do not justify such a claim, as the range between them is too great to admit of any general deduction from the three combined results. For the purposes of this discussion it would have been better if the line could have been divided into more numerous sections and if more than one comparison for the determination of the stadia factor could have been made.

A second condition is represented by the supposition that the rods were originally accurately subdivided so as to read to feet, tenths, and hundredths and that the stadia wires were at a fixed interval of 1 to 100. A correction inherent to this condition, from the theory of stadia measurement, is that of $f + c$, f corresponding to the distance from the plane of the cross wires to the objective, and c being the distance from the center of the instrument to the objective. In order to obtain a correct distance the measurement should, then, be from a point which is $f + c$, or, in the instrument used, 0.95 feet, ahead of the center of the transit. In other words, this amount should be added to the distance obtained at each transit station.

Table showing discrepancies between stadia distances affected by "$f+c$" correction and computed distances.

Section.	Stations.	Stadia distance reduced to mean sea level.	Correction for $f+c$.	Corrected distance.	Computed distance.	Discrepancy add to stadia distance.	Discrepancy.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
1...	0- 154	62,061	+146	62,207	62,276	+ 69	1 in 903
2...	154- 800	227,967	+614	228,581	228,734	+153	1 in 1,495
3...	800- 949	49,119	+142	49,261	49,190	− 71	1 in 693
4...	949-1,046	33,058	+ 92	33,150	33,174	+ 24	1 in 1,381

The mean discrepancy for the whole distance is 175 feet, or 1 in 2,133. This, it will be observed, approximates that obtained after application of the stadia-factor correction.

The results from the application of the $f+c$ correction serve to indicate that the rod was graduated approximately correctly, as intended, and the stadia wires were fixed so as to read distances on the rod approximately in the proportion of 1 to 100. As the stadia-factor correction was systematic, the results obtained for distances along the boundary line by a direct adjustment of the original stadia distances to fit the triangulation exactly correspond to those which would have been obtained if the stadia-factor correction had been first applied and the remaining discrepancy afterwards adjusted to the triangulation.

The only check obtained with reference to vertical distances or measurements of height is that furnished by the portion of the line between the Northern Pacific and Great Northern railroads. Along the former road is a line of precise levels run by the United States Geological Survey from a mean sea-level connection at Tacoma, Washington. The stadia line was connected with a bench mark of the precise levels, and this bench mark is the datum upon which the elevation of the stadia line is based. The profile of the Great Northern Railway adjusted to the United States Geological Survey precise levels furnished an elevation at Leonia to which the stadia line was joined. The resulting discrepancy was 73 feet, which is greater than might reasonably be expected, but it is possible that some of the error may be in the railroad profile.

The details relating to the profile of the boundary line between these two railroads are as follows: Sum of horizontal components, 201,188 feet; sum of vertical components, 42,700 feet; discrepancy in closure, 73 feet; discrepancy referred to horizontal components equals 1 in 2,756; discrepancy referred to vertical components equals 1 in 585.

Extensive and careful experiments with the stadia were made by the

GRANITE BOUNDARY-LINE MONUMENTS.

The monument on the right was cut in ten sections for transportation on pack animals.

Boundary Commission engaged in the survey and re-marking of the boundary between the United States and Mexico west of the Rio Grande; and as the conclusions reached so nearly correspond to those arrived at in connection with the Idaho-Montana line, the following quotations are made:

> The method by stadia is cheap and rapid; requires less cutting than that by chain; is carried on under the eye of an instrument man, presumably of a high order of intelligence; gives heights and angles, and enables objects to be located from the line which is being measured; is ordinarily more accurate than the chain, and can be successfully used where the chain can not be, experience on this survey having shown that the stadia lines over mountains, hills, and canyons were more accurate than those on level plains and wide valleys. * * *
>
> In view of this proof of the inevitable change in the value of the interval, the common practice of painting a rod to correspond with the stadia interval of a certain hour and day and then continuing the use of such rod unchecked and unchanged during the widely different seasons of this country oftentimes—in fact, for many years at a time—is seen to be inviting the large systematic error which almost without exception characterizes such work. If this evidence be taken to prove the fact that even so-called fixed stadia wires actually change their relative positions, or, what amounts to the same thing, appear to change on account of the influence of differential refraction at different seasons, then the present method of painting the rod to correspond with the determined interval is objectionable because of the cost of regraduating and repainting the rod to correspond to such change in interval. A method entirely free from this objection of cost, and one which the writer has found to stand every test during several years of field use, is that which uses rods divided into true units of feet, yards, or meters and employs an interval factor in the computation of distances. With this system a change in the interval simply means the loss of an hour's time in the preparation of a new table for reduced or true distances corresponding to any rod reading.

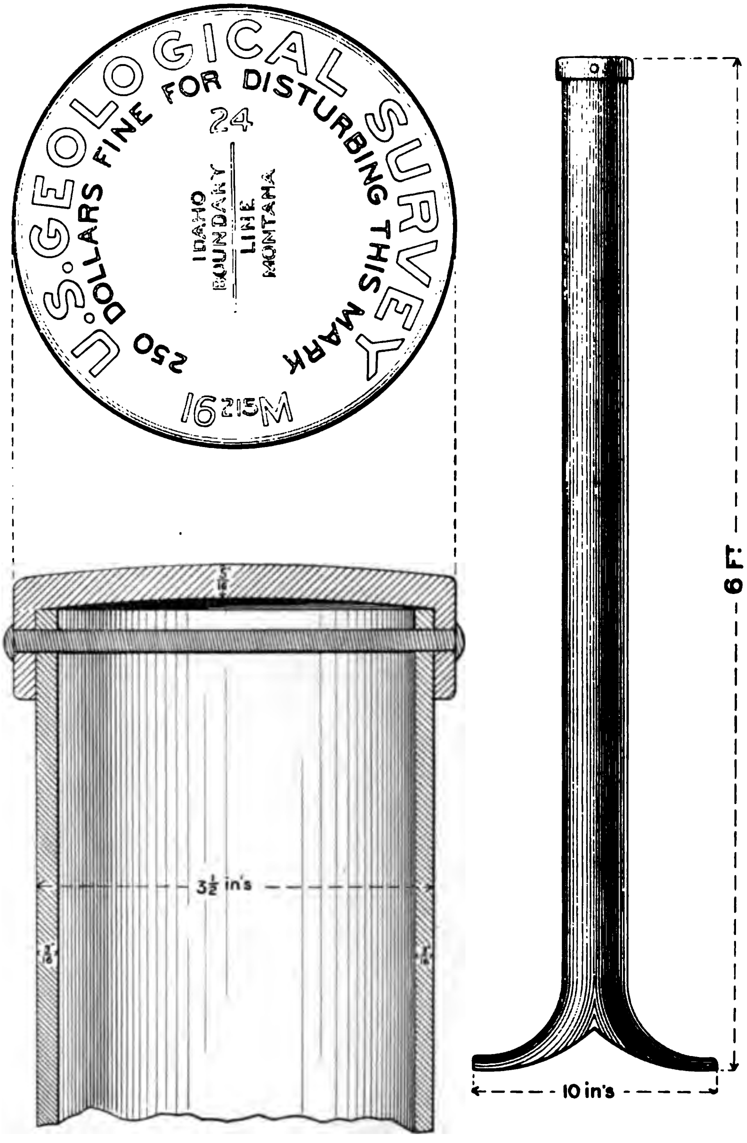
MONUMENTS.

The monuments used along the meridional portion of the line are of two kinds—stone and iron. The stone monuments are of granite, 6 feet in length and 10 inches square, undressed except for spaces sufficient to permit cutting the words "Idaho" and "Montana," on opposite sides. These monuments are placed in the more prominent localities, and are monolithic in all cases where it was possible to transport them in one mass to the proper position; otherwise they were cut into ten sections, so that they could be carried on pack mules, and were bolted and cemented together when established in place. The monuments at the international boundary and at the summit of the Bitterroot Mountains, these being the terminal points of the meridional portion of the line, are of stone made from sections, as described, and monoliths are placed near the points at which the boundary line crosses the Northern Pacific and Great Northern railways. (See Pl. VII.) The iron monuments are hollow posts of wrought iron, 6 feet in length and about 4 inches in outer diameter, covered with a coat of asphaltum tar. At the bottom they are flared to a width of 12 inches, to insure more secure planting. These posts are set to a depth of 3 feet below the surface of the ground, 3 feet remaining above ground, and a conical mound of earth being raised around them to a height of 2 feet. On the tops of the posts are riveted bronze caps, on which is cut appropriate lettering, and the number of the monument and the distance (in miles) from the international boundary are stamped in large figures. (See Pl. VIII.) In addition to the four stone monuments referred to, eighty-nine iron monuments were placed. The sites for the monuments were chosen with reference to the topographic features of the country, instead of being placed at even miles, as has usually been the custom on boundary lines, but there are few intervals greater than a mile between the monuments, the average interval being about three-fourths of a mile. They were placed generally on summits, or near streams, roads, or trails, and so as to be intervisible when possible. Between the monuments the line is thoroughly cut out, and adjacent trees are blazed, so that it can be readily recognized in any locality.

The stone monuments were quarried at Medical Lake, Washington, and cost $14.50 apiece delivered at the railroad station nearest the point at which they were established. The iron posts were made in St. Louis, and cost $2.08½ delivered to the United States quartermaster at St. Louis.

Previous to the work herein referred to no attempt had ever been made to locate and mark the Idaho-Montana boundary line, but the engineers of the Northern Pacific and Great Northern railways had estimated the points at which it crossed their tracks and established marks according to this estimation. The accepted crossing on the Northern Pacific was found to be about one-fourth of a mile west of the true line and that of the Great Northern about 1 mile east of the true line along the railway track, but only about a half mile east thereof in direct longitude. Kootenai County, Idaho, spent a considerable sum of money in grading a road up the mountain from Leonia toward Sylvanite, which, when the boundary line was located soon after, was found to be in Flathead County, Montana.

Each monument is witnessed by pits and mounds wherever practicable, the pits being dug across the line distant 4 feet north and south of the post, and the mounds being 4 feet east and west thereof. The dimensions of the pits are 3 by 2 by 1½ feet, and the mounds were constructed from the excavated material. The monuments are further witnessed, usually by four blazed bearing trees, one in each quadrant. The two trees in Idaho at post 48, for instance, were deeply engraved "Idaho P. 48 B. T.," and the two trees in Montana were marked in a corresponding manner. (See Pl. IX.) Under each monument was placed about a quart of charcoal. In the notes the distance and bearing to the witness trees were marked and the trees described.



DESIGN FOR IRON POST.

Complete copies of these notes can be found in the offices of the Geological Survey and the General Land Office in Washington and of the surveyors-general in Idaho and Montana.

A general description of the monuments is given below. The figures followed by the letter "M" indicate the distance in miles and hundredths of a mile from the initial monument.

Initial monument: Stone masonry monument, 6 feet long, 10 by 10 inches square, consisting of ten sections cemented and bolted together. An aluminum bench-mark tablet is set with cement in the top of the monument stamped "1899, Elev. 4500." The monument stands amid tall, dense timber on west slope of ridge, about a half mile east of creek.

1. Iron post, stamped "0.40 M.," on west slope of ridge, amid tall, dense timber.

2. Iron post, stamped "1.15 M.," on west slope of ridge, amid tall, dense timber.

3. Iron post, stamped "1.82 M.," on west slope of ridge, amid tall, dense timber.

4. Iron post, stamped "2.85 M.," on top of a ridge making out from the west slope of the main ridge, amid tall, dense timber.

5. Iron post, stamped "3.68 M.," between two branches, 30 feet apart, of a small creek flowing west, about a half mile east of the junction of said creek with a creek flowing north, amid dense timber.

6. Iron post, stamped "4.66 M.," 30 feet south of a creek flowing west and about one-fourth mile east of the junction of said creek with a creek flowing north, amid dense timber.

7. Iron post, stamped "5.415 M.," amid dense timber, 300 feet south of a small creek flowing west, and about one-fourth mile east of creek flowing northwest.

8. Iron post, stamped "6.295 M.," 2.5 miles north of the Buckhorn mine, on bare grassy ridge, 100 feet east of edge of green timber. A lone fir tree stands 200 feet east of the post.

9. Iron post, stamped "6.825 M.," 1¾ miles north of the Buckhorn mine, amid heavy fir timber, on west slope of high timbered ridge.

10. Iron post, stamped "7.53 M.," 1 mile north of the Buckhorn mine, on top of ridge, amid fir timber.

11. Iron post, stamped "8.21 M.," in north end of basin, at south edge of green timber, 100 feet east of foot of slope.

12. Iron post, stamped "8.61 M.," on top of bare ridge, a half mile east of the Buckhorn cabins.

13. Iron post, stamped "9.03 M." (post should have been stamped "9.00 M."), on top of bare rocky ridge, a half mile south of the Buckhorn mines, about 600 feet southeast from the highest point on the ridge.

14. Iron post, stamped "9.505 M." (post should have been stamped

"9.47 M."), on south edge, about halfway between the top of ridge and creek, on a small secondary ridge bearing S. 60° W., amid scattering fir timber, just north of an open space.

15. Iron post, stamped "10.16 M.," amid dense timber, on south bank of a creek flowing west, about 330 feet north of another creek flowing in same direction.

16. Iron post, stamped "11.005 M.," amid heavy timber, on top of a ridge on main west slope.

17. Iron post, stamped "11.49 M.," amid dense timber, on top of high ridge bearing west.

18. Iron post, stamped "12.12 M.," on top of a heavily timbered ridge south of creek in deep ravine, and a half mile east of creek flowing northwest.

19. Iron post, stamped "12.915 M.," 20 feet north of creek flowing northwest, about 1 mile north of Windy Pass trail.

20. Iron post, stamped "13.70 M.," on top of timbered ridge, 30 feet south of Windy Pass trail, three-fourths of a mile north of Skin Creek.

21. Iron post, stamped "14.40 M.," on top of north bank, 100 feet distant from Skin Creek, amid heavy timber.

22. Iron post, stamped "14.86 M.," 1¼ miles north of summit of Yak Mountain, a half mile south of Skin Creek, on top of heavily timbered ridge bearing northeast.

23. Iron post, stamped "15.62 M.," a half mile north of summit of Yak Mountain, on rocky ridge one-fifth of a mile northeast from Buckhorn triangulation station, amid scattering fir timber.

24. Iron post, stamped "16.215 M.," 10½ miles north of Leonia, on summit of Yak Mountain, 30 feet east of the highest point of the right-hand peak of three which are on the northwest end of the range as seen from the vicinity of Leonia. A signal tree stands 32 feet south and 2 feet east of the post. This post is visible from the whole surrounding country.

25. Iron post, stamped "16.81 M.," 9¾ miles north of Leonia, amid heavy timber, on slope of Yak Mountain, 0.6 mile south of the summit.

26. Iron post, stamped "17.50 M.," 9.1 miles north of Leonia, on top of a heavily timbered east-west ridge, on slope of Yak Mountain.

27. Iron post, stamped "18.05 M.," 8½ miles north of Leonia, one-fourth of a mile north of Curly Creek, on the south edge of a bench, at southern edge of thick growth of small pines.

28. Iron post, stamped "19.06 M.," 7½ miles north of Leonia, 1 mile north of Kinzie's ranch, at foot of mountain 2 miles west of Cross triangulation station, one-fifth of a mile north of Kingsley Creek, amid heavy timber.

29. Iron post, stamped "19.79 M.," 6¾ miles north of Leonia, amid heavy timber, 300 feet north of edge of meadow at Kinzie's ranch and *10 feet north* of trail leading northwest from that ranch.

30. Iron post, stamped "20.40 M.," 6.1 miles north of Leonia, one-

POST 48, AT SUMMIT OF TIMBERED RIDGE.

fourth of a mile north of Newton's house, at north end of meadow, where a large spring comes out, 10 feet south of wagon road, 200 feet west of foot of hill.

31. Iron post, stamped "21.22 M.," 5.4 miles north of Leonia, a half mile south of Newton's house, at southeast corner of large meadow, at west edge of timber, and 75 feet east of Curly Creek.

32. Iron post, stamped "21.73 M.," 4.9 miles north of Leonia, about 1 mile north of Lang's ranch, 500 feet south of Curly Creek, and 10 feet north of wagon road.

33. Iron post, stamped "22.23 M.," 4.4 miles north of Leonia, 0.3 mile north of where the line crosses a valley just west of Lang's ranch, amid heavy timber on side hill, about midway between valley on the west and top of hill on the east.

34. Iron post, stamped "23.12 M.," 3.5 miles north of Leonia, 0.2 mile south of where the boundary line crosses Curly Creek, amid heavy timber on west slope, about 600 feet east of Curly Creek.

35. Iron post, stamped "24.10 M.," 2.5 miles north of Leonia, on top of a ridge bearing N. 30° E., where the line ascends from Curly Creek bottom, amid dense timber.

36. Iron post, stamped "24.965 M.," 1.7 miles north of Leonia, on high ground, 0.2 mile north of Lime Creek.

37. Iron post, stamped "25.79 M.," 0.9 mile north of Leonia, 10 feet south of wagon road, amid heavy timber.

38. Iron post, stamped "26.14 M.," a half mile north of Leonia, on top of east bank of Kootenai River, 180 feet above surface of water.

39. Stone monument, 6 feet by 10 inches by 10 inches, with an aluminum bench-mark tablet, stamped "26.64 M.," cemented in its top, located at Leonia, near foot of hill west of Great Northern Railway monument; bears S. 5° W., 584 feet distant from depot chimney. (See Pl. XI, *A*.)

40. Iron post, stamped "27.45 M.," 0.9 mile south of Leonia, at north edge of large timber and at south edge of brush, on steep east slope.

41. Iron post, stamped "28.215 M.," 1.6 miles south of Leonia, on flat amid heavy timber and dense underbrush, a half mile southwest of the Keeler cabins.

42. Iron post, stamped "29.115 M.," 2.5 miles south of Leonia, 0.3 mile south of a creek flowing east and 0.4 mile north of a creek flowing southeast into Star Creek, on top of a ridge bearing S. 45° E., amid thick small pines. (See Pl. X.)

43. Iron post, stamped "30.03 M.," 3.4 miles south of Leonia, on top of south bank of deep ravine, one-fifth of a mile west of where it joins a creek flowing southeast; amid heavy timber.

44. Iron post, stamped "31.03 M.," 4.4 miles south of Leonia, 1 mile north of Star Creek, amid heavy timber, on small ridge 200 feet north of small stream flowing east.

45. Iron post, stamped "32.17 M.," 5.5 miles south of Leonia, 200 feet south of Star Creek, a half mile below the mouth of a creek which empties into Star Creek from the southwest, about 600 feet above the mouth of a ravine which enters Star Creek from the southeast, and about 50 feet higher than the bed of creek; amid large timber.

46. Iron post, stamped "33.01 M.," 6.4 miles south of Leonia, 0.9 mile south of Star Creek, amid large scattering pine trees and dense small pines, on top of an east-west ridge about midway between Star Creek on the west and the top of high ridge on the east.

47. Iron post, stamped "33.74 M.," 7.2 miles south of Leonia, on steep slope draining west into Star Creek, 150 feet north of a small stream bearing N. 45° E., amid dead and scattering live timber.

48. Iron post, stamped "34.755 M.," 8.2 miles south of Leonia, on top of high timbered ridge, bearing SW.-NE., which forms the divide between Star and Callahan creeks. A line 20 feet in width was cut in the timber and can be seen from the summit of Yak Mountain and intermediate points to the north and from the summit of the Cabinet Mountains and intermediate points to the south. (See Pl. IX.)

49. Iron post, stamped "35.37 M.," 3.4 miles north of west fork of Callahan Creek, on top of a heavily timbered ridge bearing east-west, about a half mile east of the junction of said ridge with the main ridge, the point of junction being the highest point on the main ridge.

50. Iron post, stamped "36.31 M.," 2.5 miles north of the west fork of Callahan Creek, on top of a timbered ridge bearing NW.-SE., about 1,000 feet northwest of a trapper's cabin, in saddle on said ridge.

51. Iron post, stamped "36.86 M.," 2 miles north of the west fork of Callahan Creek, on west point of ridge, amid dead and scattering live trees about one-fourth of a mile west of top of high ridge bearing east.

52. Iron post, stamped "37.52 M.," 1.3 miles north of the west fork of Callahan Creek, on top of a bare ridge bearing southeast, about halfway between the top of the ridge on the west and a deep ravine on the east.

53. Iron post, stamped "38.57 M.," 0.25 mile north of the west fork of Callahan Creek, one-fourth of a mile west of a deep ravine from the north, on point of ridge bearing southeast, amid scattering trees and brush.

54. Iron post, stamped "39.59 M.," on top of high timbered ridge between the west and main forks of Callahan Creek.

55. Iron post, stamped "40.51 M.," in Callahan Creek bottom, 50 feet west of bank of creek and just east of the old Lightning Creek trail, amid large, dense timber.

56. Iron post, stamped "41.51 M.," 1 mile south of Callahan Creek on high, flat ridge bearing nearly east-west, amid tall timber.

POST 42, AND LINE CUT THROUGH TIMBER.

57. Iron post, stamped "42.35 M.," 1.8 miles south of Callahan Creek on top of timbered ridge bearing NE.–SW.

58. Iron post, stamped "43.50 M.," on top of high-timbered ridge which forms the divide between Callahan and Keeler creeks, near the head of the east fork of Callahan Creek.

59. Iron post, stamped "44.16 M.," on point of ridge between and about 300 feet west from the junction of two gulches which form the north branch of Keeler Creek, amid dense timber.

60. Iron post, stamped "44.72 M.," on top of heavily-timbered ridge bearing S. 60° E., between two forks of Keeler Creek.

61. Iron post, stamped "45.10 M.," in deep canyon, 50 feet south of the west fork of Keeler Creek, amid heavy timber.

62. Iron post, stamped "46.01 M.," on top of high east–west timbered ridge between two west forks of Keeler Creek.

63. Iron post, stamped "46.68 M.," amid heavy timber on top of bench 600 feet north and about 100 feet above the west fork of Keeler Creek, about a half mile west of the junction of the west fork with the main branch of that creek.

64. Iron post, stamped "47.78 M.," 150 feet north and 40 feet above Keeler Creek, which bears N. 30° E., nearly opposite the mouth of a canyon in the cliffs on east side of creek, at the east edge of timber.

65. Iron post, stamped "48.67 M.," 2.35 miles north of the east fork of Lightning Creek, on top of the east–west rocky ridge which forms the divide between Keeler and Lightning creeks, about 400 feet west of a saddle and 100 feet east of a hump on the ridge.

66. Iron post, stamped "49.54 M.," 1.5 miles north of the east fork of Lightning Creek, on top of a grassy east–west ridge, about 600 feet east of a peak where the ridge joins a north–south ridge, amid scattering fir trees.

67. Iron post, stamped "50.09 M.," 0.9 mile north of the east fork of Lightning Creek, at the top of slope, in top of rocks on southeast end of a ridge.

68. Iron post, stamped "50.99 M.," on bench 435 feet north of the east fork of Lightning Creek and about 200 feet higher than the creek, amid heavy timber nearly opposite the mouth of a ravine on south side of creek.

69. Iron post, stamped "51.85 M.," on top of high rocky ridge between two east forks of Lightning Creek, in top of rock ledge.

70. Iron post, stamped "52.725 M.," 10 feet south of the east fork of Lightning Creek, amid large timber.

71. Iron post, stamped "53.24 M.," a half mile south of the east fork of Lightning Creek, 1 mile north of summit of Cabinet Mountains, on top of ridge bearing N. 15° E., amid scattering pine and fir trees.

72. Iron post, stamped "54.22 M.," on summit of Cabinet Mountains, between the head waters of East Lightning and West Blue

creeks, about 1,000 feet northeast from a peak, at west edge of small fir trees and grass, where rocks begin in ascending the peak, about one-third mile west of a saddle on summit ridge. This point is visible from post 24 on the summit of the Yak Mountains and from all prominent intermediate points, also from post 92, on the summit of the Bitterroot Mountains and from intermediate points.

73. Iron post, stamped "54.905 M.," on top of narrow rocky ridge bearing S. 36° E., 0.7 mile south of the summit of the Cabinet Mountains, 0.4 mile south of basin at head of West Blue Creek, amid scattering fir and pine trees.

74. Iron post, stamped "55.58 M.," on top of rock ledge 1.4 miles south of the summit of the Cabinet Mountains, 0.7 mile north of West Blue Creek, on east slope of rocky ridge, 0.6 mile east of the triangulation station Blacktop, and 900 feet south of a small stream flowing east.

75. Iron post, stamped "56.285 M.," 2.1 miles south of the summit of the Cabinet Mountains, 30 feet east of West Blue Creek, 120 feet south of where line crosses creek under high cliffs on east side of creek, 8 feet south of a 36-inch hemlock stump and amid heavy timber.

76. Iron post, stamped "57.14 M.," 2.9 miles south of the summit of the Cabinet Mountains, on west side of West Blue Creek and 173 feet south of where line crosses it, opposite almost perpendicular cliffs on the east side of creek, about 0.25 mile above the mouth of a canyon from the northeast, amid large timber just west of an old trail.

77. Iron post, stamped "57.975 M.," 3.7 miles south of the summit of the Cabinet Mountains, on a small bench on steep rocky slope, one-fourth mile east of West Blue Creek.

78. Iron post, stamped "58.93 M.," 4.7 miles south of the summit of the Cabinet Mountains, on top of a narrow ridge, 200 feet above West Blue Creek and about opposite the south end of a long ridge on the west side of the creek, amid scattering pine trees.

79. Iron post, stamped "59.975 M.," 3 miles north of Clark Fork of Pend Oreille, on top of north bank of West Blue Creek at south side of large flat; in open ground.

80. Iron post, stamped "60.79 M.," 2.1 miles north of Clark Fork, on flat ground, amid heavy, dense timber, about 600 feet west of edge of bench, where the surface descends to West Blue Creek. An old trail crosses the line 150 feet south of the post.

81. Iron post, stamped "61.605 M.," 1.3 miles north of Clark Fork, on top of flat ridge, amid heavy timber, 30 feet southeast of a pond 100 feet in diameter.

82. Iron post, stamped "62.35 M.," 0.5 mile north of Clark Fork, on top of flat east-west ridge, amid heavy timber.

83. Stone monument 6 feet long, 10 inches by 10 inches square, with an aluminum bench-mark tablet stamped "63.03 M." cemented

A. GRANITE MONUMENT ON BOUNDARY LINE NEAR LEONIA, IDAHO.

B. SECTIONAL MONUMENT AT SUMMIT OF BITTERROOT MOUNTAINS.

in its top, located 7 feet north of the Northern Pacific Railway, 1 mile eastward from Cabinet, Idaho, 450 feet eastward from sign "1 mile to Cabinet," 150 feet eastward from a cut at sharp curve in railroad track.

84. Iron post, stamped "63.98 M.," 1 mile south of the Northern Pacific Railway, 0.2 mile northward from Baker's house, amid heavy timber on south bank of small stream flowing N. 75° W.

85. Iron post, stamped "64.95 M.," 1.9 miles south of the Northern Pacific Railway at the foot of mountain, 100 feet west of the mouth of a small stream in deep ravine; amid heavy timber.

86. Iron post, stamped "65.70 M.," 2.7 miles south of the Northern Pacific Railway, under west brow of a long, narrow ridge, about 300 feet south from where the ridge begins steep descent; amid dense timber.

87. Iron post, stamped "66.50 M.," 3.5 miles south of the Northern Pacific Railway, on top of high east-west ridge, about 300 feet east of its junction, with a north-south ridge; amid scattering large timber.

88. Iron post, stamped "67.46 M.," on top of high east-west timbered ridge, 1 mile north of the west fork of Elk Creek, about one-fourth mile east of where the ridge joins north and south ridge.

89. Iron post, stamped "68.475 M." (post should have been stamped "68.44 M."), in heavily timbered bottom, 60 feet north of the dry bed of the west fork of Elk Creek, about 1 mile west of the mouth of a creek from the southwest.

90. Iron post, stamped "69.08 M.," on top of narrow east-west ridge between the west fork of Elk Creek and a small stream from the southwest, amid timber.

91. Iron post, stamped "69.76 M.," on top of nearly bare ridge between two ravines bearing northeast.

92. Stone masonry monument, 6 feet long, 10 inches by 10 inches square, consisting of ten sections cemented and bolted together. An aluminum bench mark stamped "92–70.717 M., 4,850 feet" is cemented into the top of the monument. The monument stands on the top of a bare grassy ridge, amid scattering dead trees, at the junction of a ridge from the west with said ridge. The ridge at this point bears NW.-SE. and forms the summit of the Bitterroot Mountains. (See Pl. XI, *B*.)

It will be recalled that it has been previously mentioned that an error was made in the field computation, the result of which was to locate the starting point of the random line 177 feet east of the true point. The transitman did not know of this error when he surveyed the random line, but as a result of a personal equation introduced into his work his line varied from a true line by a constant swing toward the west, so that when he reached the international boundary the point on the random line was 43 feet east of the true point. Thus, in about 71 miles the transitman ran a line which at its terminal point was 134 feet "out" in azimuth. With this explanation the following table is self-explanatory:

Table showing number and kind of monuments, distances, elevations, magnetic declinations and time of magnetic observations along the boundary.

Number of monument.	Distance from international boundary.	Elevation at monument.	Distance west from random line.	Kind of monument.	Magnetic declination (east).		Time of magnetic observation.
	Miles.	*Feet.*	*Feet.*		°	′	
0......	0.00	4,505	43	Stone			
1......	0.40	4,691	49	Iron post.	23	10	9 a. m., Oct. 31, 1898.
2......	1.15	5,008	59.5	.....do....	23	02	1 p. m., Oct. 30, 1898.
3......	1.82	5,186	65	.....do....	23	15	8 a. m., Oct. 30, 1898.
4......	2.85	5,496	74	.....do....	23	18	1.30 p. m., Oct. 28, 1898.
5......	3.68	5,223	79.8	.....do....	23	06	3 p. m., Oct. 27, 1898.
6......	4.66	5,167	82	.....do....	23	00	3 p. m., Oct. 26, 1898.
7......	5.415	5,477	82.5	.....do....	23	08	8.30 a. m., Oct. 26, 1898.
8......	6.295	6,124	83.5	.....do....	23	08	11 a. m., Oct. 25, 1898.
9......	6.825	5,954	84	.....do....	23	02	3 p. m., Oct. 22, 1898.
10......	7.53	6,069	85	.....do....	23	02	8 a. m., Oct. 22, 1898.
11......	8.21	5,712	86	.....do....	23	03	1 p. m., Oct. 21, 1898.
12......	8.61	6,116	87	.....do....	.....	.....	
13......	*a* 9.00	6,161	87	.....do....	22	54	10 a. m., Oct. 21, 1898.
14......	*b* 9.47	6,612	88	.....do....	23	05	1 p. m., Oct. 20, 1898.
15......	10.16	4,595	89	.....do....	23	02	4 p. m., Oct. 19, 1898.
16......	11.005	5,514	90	.....do....	22	55	2 p. m., Oct. 18, 1898.
17......	11.49	5,407	91	.....do....	22	52	3.45 p. m., Oct. 17, 1898.
18......	12.12	5,200	91.5	.....do....	23	12	9 a.m., Oct. 17, 1898.
19......	12.915	4,375	93	.....do....	23	05	1 p. m., Oct. 15, 1898.
20......	13.70	5,700	94	.....do....	22	45	2 p. m., Oct. 10, 1898.
21......	14.40	4,374	95	.....do....	23	01	8 a. m., Oct. 10, 1898.
22......	14.86	5,448	95	.....do....	22	57	8.30 a. m., Oct. 8, 1898.
23......	15.62	6,290	96	.....do....	22	43	Noon, Oct. 7, 1898.
24......	16.215	6,627	96	.....do....	.....	.....	
25......	16.81	5,406	97	.....do....	23	03	5 p. m., Oct. 3, 1898.
26......	17.50	4,966	98	.....do....	23	25	1 p. m., Oct. 3, 1898.
27......	18.05	3,817	98	.....do....	22	30	5 p. m., Oct. 2, 1898.
28......	19.06	2,864	99	.....do....	23	00	10.30 a. m., Oct. 2, 1898.
29......	19.79	2,523	100	.....do....	23	08	1 p. m., Oct. 1, 1898.
30......	20.40	2,504	100.5	.....do....	23	05	8 a. m., Oct. 1, 1898.
31......	21.22	2,490	101	.....do....	23	02	9 a. m., Sept. 30, 1898.
32......	21.73	2,520	102	.....do....	22	59	4.30 p. m., Sept. 28, 1898.
33......	22.23	2,694	102	.....do....	22	50	11 a. m., Sept. 28, 1898.
34......	23.12	2,541	103	.....do....	22	56	1.30 p. m., Sept. 26, 1898.
35......	24.10	2,418	104	.....do....	23	00	8.30 a. m., Sept. 26, 1898.
36......	24.965	2,425	105	.....do....	22	50	1.30 p. m., Sept. 24, 1898.
37......	25.79	2,199	106	.....do....	22	08	4.30 p. m., Sept. 23, 1898.
38......	26.14	1,978	107	.....do...	.....	.....	
39......	26.64	1,833	107	Stone	22	45	1 p. m., Sept. 23, 1898.
40......	27.45	2,678	107	Iron post.	22	48	8 a. m., Sept. 23, 1898.
41......	28.215	3,021	108	.....do....	22	39	1.30 p. m., Sept. 20, 1898.
42......	29.115	3,546	109	.....do....	22	35	2.30 p. m., Sept. 19, 1898.

a Stamped 9.03.

b Stamped 9.505.

CLARK FORK OF COLUMBIA RIVER JUST WEST OF BOUNDARY LINE.

Table showing number and kind of monuments, etc.—Continued.

Number of monument.	Distance from international boundary.	Elevation at monument.	Distance west from random line.	Kind of monument.	Magnetic declination (east).		Time of magnetic observation.
	Miles.	*Feet.*	*Feet.*		°	′	
43	30.03	3,533	110	Iron post	22	33	5 p. m., Sept. 18, 1898.
44	31.03	3,357	112	....do	22	45	1 p. m., Sept. 16, 1898.
45	32.17	3,162	114	....do	....		
46	33.01	4,410	115	....do	22	27	1 p. m., Sept. 14, 1898.
47	33.74	4,392	116	....do	22	40	4.30 p. m., Sept. 12, 1898.
48	34.755	6,127	118	....do	22	38	8 a. m., Sept. 12, 1898.
49	35.37	5,993	119	....do	22	25	11 a. m., Sept. 10, 1898.
50	36.31	5,535	120	....do	22	15	2 p. m., Sept. 9, 1898.
51	36.86	5,572	121	....do	22	43	9 a. m., Sept. 9, 1898.
52	37.52	4,740	182	....do	21	26	12.30 p. m., Sept. 7, 1898.
53	38.57	3,498	109	....do	....		
54	39.59	4,433	123	....do	22	39	12.30 p. m., Sept. 5, 1898.
55	40.51	3,089	125	....do	22	35	2.30 p. m., Sept. 4, 1898.
56	41.51	4,792	126	....do	22	25	4 p. m., Sept. 3, 1898.
57	42.35	5,446	127	....do	22	10	2.30 p. m., Sept. 2, 1898.
58	43.50	5,870	129	....do	22	12	12.30 p. m., Aug. 29, 1898.
59	44.16	4,887	131	....do	22	15	1.30 p. m., Aug. 27, 1898.
60	44.72	5,107	132	....do	22	05	3 p. m. Aug. 26, 1898.
61	45.10	3,992	133	....do	22	23	9 a. m., Aug. 26, 1898.
62	46.01	5,176	134	....do	25	20	2.30 p. m. Aug. 24, 1898.
63	46.68	3,867	135.5	....do	21	45	5 p. m. Aug. 23, 1898.
64	47.78	4,052	137	....do	22	02	4.30 p. m., Aug. 20, 1898.
65	48.67	5,666	139	....do	22	20	2 p. m., Aug. 19, 1898.
66	49.54	5,781	139	....do	22	35	9 a. m., Aug. 19, 1898.
67	50.09	5,822	139	....do	22	28	2.30 p. m., Aug. 13, 1898.
68	50.99	3,623	141	....do	22	20	2.30 p. m., Aug. 12, 1898.
69	51.85	5,902	141	....do	23	10	10 a. m., Aug. 11. 1898.
70	52.725	4,084	142	....do	22	35	10 a. m., Aug. 9, 1898.
71	53.24	5,366	142	....do	22	30	3 p. m., Aug. 8, 1898.
72	54.22	6,780	163	....do	23	14	8 a. m., Aug. 8, 1898.
73	54.905	6,197	163	....do	22	28	7.30 a. m. Aug. 6, 1898.
74	55.58	5,349	164	....do	21	50	1 p. m. Aug 5, 1898.
75	56.285	4,139	165	....do	23	10	8.45 a. m., Aug. 3, 1898.
76	57.14	3,774	166	....do	22	30	11 a. m., July 30, 1898.
77	57.975	3,856	166	....do	22	52	6.30 p. m., July 28, 1898.
78	58.93	4,206	167	....do	23	05	10 a. m., July 28, 1898.
79	59.975	2,655	168	....do	22	33	1.30 p. m., July 27 1898.
80	60.79	2,662	169	....do	22	15	Noon, July 26, 1898.
81	61.605	2,667	169	....do	22	27	4 p. m., July 24, 1898.
82	62.35	2,487	170	....do	22	32	1.30 p. m., July 22, 1898.
83	63.03	2,225	170	Stone	22	22	3 p. m., July 21, 1898.
84	63.98	2,416	171	Iron post	22	22	3.45 p. m., July 20, 1898.
85	64.94	2,501	172	....do	22	26	9.30 a. m., July 19, 1898.
86	65.70	3,990	173	....do	22	20	12.30 p. m., July 18, 1898.
87	66.50	4,953	173	....do	22	04	10.30 a. m., July 16, 1898.
88	67.46	4,793	174	....do	22	20	4 p. m., July 14, 1898.
89	*a* 68.44	2,667	175	....do	22	20	11 a. m., July 13, 1898.
90	69.08	4,341	176	....do	22	20	11 a. m., July 12, 1898.
91	69.76	3,555	176	....do	....		
92	70.717	4,848	177	Stone	22	15	10.30 a. m., July 9, 1898.

a Stamped 68.475.

THE INTERNATIONAL BOUNDARY WEST OF THE SUMMIT OF THE ROCKY MOUNTAINS, AND THE MOOYIE TRAIL MONUMENT.

On August 11, 1856, a law was passed by Congress authorizing the appointment of a commission to unite with a similar commission to be appointed by Great Britain for the purpose of carrying into effect the first article of the treaty of June 15, 1846, that is to determine and mark the boundary line between the United States and British possessions westward from the summit of the Rocky Mountains. In February, 1857, Mr. Archibald Campbell was appointed commissioner for the United States, and Lieut. John G. Parké, United States Army, was appointed chief astronomer and surveyor. Three commissioners were appointed by Great Britain. Captains Prevost and Richards, of the Royal Navy, were first and second commissioners, respectively, their duties being limited to the determination of the water boundary referred to as "the channel which separates the Continent from Vancouver's Island." In the summer of 1858, Col. J. S. Hawkins, Royal Engineers, appointed by the British Government commissioner to determine the boundary line along the forty-ninth parallel, arrived in the United States prepared for field operations. At a meeting of the joint commission the following agreement relating to the plan of work was entered into:

> After discussing plans for determining and marking the line as far eastward as the Cascade Mountains, it was concluded to be inexpedient at the present time, in consequence of the great expense, consumption of time, and the impracticable nature of the country, to mark the whole boundary by cutting a track through the dense forest.
>
> It was therefore agreed to ascertain points on the line by the determination of astronomical points at convenient intervals on or near the boundary and to mark such astronomical stations, or points fixed on the parallel forming the boundary, by cutting a track of not less than 20 feet in width on each side for the distance of half a mile or more, according to circumstances. Further, that the boundary be determined and similarly marked where it crosses streams of any size, permanent trails, or any striking natural feature of the country.
>
> In the vicinity of settlements on or near the line it is deemed advisable to cut the track for a greater distance and to mark it in a manner to be determined hereafter.

Under this plan it seems that the work was prosecuted through the field seasons of 1858, 1859, and 1860, but owing to the war between the States, which followed soon after, all operations were suspended, and no detailed report was ever published.

The following is an extract from a short report by Mr. Archibald Campbell, United States commissioner, published in House Executive Document No. 86, Fortieth Congress, third session:

> The work of running and marking the land boundary was carried on through a country previously almost unknown. The forty-ninth parallel extends over rugged and precipitous mountains that attain great elevation, and in the Cascade

Range, on and near the boundary, perpetual snow covers many of the peaks, whose northern gorges are filled up with immense glaciers. The timber on the western slope of the Cascade Mountains is dense, being a heavy growth of pine and fir that in many places stands over a fallen forest not yet decayed. This is the character of the country as far eastward as the valley of the Similkameen River, one of the tributaries of the Columbia. Here the timber becomes more open and surveying operations less difficult.

After passing the Okinokane River, which is the lowest line of the great valley between the Cascade and the Rocky Mountains, the country again becomes rough and the timber more dense, but less so than the western slope of the Cascade Mountains.

It being impossible to follow the forty-ninth parallel continuously, the line of survey was carried over the nearest practicable route for a pack trail, connecting each astronomical station, making a total length of line of survey of about 800 miles. Astronomical stations were established by parties of the joint commission at almost every accessible point from which the boundary line is ascertained, and marked by a vista across all valleys and trails, where rough stone monuments were erected over posts buried in the ground to indicate the exact line.

The reconnoissance work extends over an area of about 30,000 square miles. Within this space the barometrical heights of over 800 points have been obtained.

A magnetic survey, extending over a range of 30° 20′ in latitude and 4° in longitude, with the necessary observations of the magnetic elements of the astronomical stations, was also made.

The entire length of the land boundary line is over 9° in longitude, or about 410 miles, and the length of the route traveled in surveying it is double that distance. Trails had to be opened for three-fourths of the distance traveled, involving great labor in cutting, grading, and bridging to make the route practicable for pack-mule transportation. The water courses were numerous and rapid, rendering the fords frequent and dangerous, and a slight rise of many of the streams would have made them impassable but for the timely precaution of building bridges at small streams and ferryboats at the river crossings. Many of the trails opened are now traveled routes to the mines then and since discovered, which are rapidly developing that section of the country, where almost every valley of any extent affords facilities for agricultural pursuits.

In collating the results of the survey reports upon the geology, botany, and natural history of the country reconnoitered were prepared and complete maps, on a large scale, made of the entire boundary and the adjacent country. A general map has also been made, showing the extent of the country traversed. And to facilitate the survey of the public lands photographic duplicates of the detailed sheets, showing each monument on the boundary line, with its geographical position, were furnished to the General Land Office. Photographic duplicates of the detailed sheets of the water boundary have also been made and furnished the Department of State in illustration of the question of the boundary channel.

Copies of the maps referred to in Mr. Campbell's reports are in existence. The boundary-line maps are in 14 sheets, with the title, Detailed Maps of the Northwest Boundary, from Point Roberts to the Rocky Mountains, between the United States and the British Possessions, under the treaty of June 15, 1846, showing monuments, cuts, and other marks. The scale of the maps is 1:60,000, and the topography is shown in hachures. The general map referred to is in contours and apparently on the same scale as the detailed maps.

From an inspection of the detailed map it appears that there are two portions of the boundary line which seem to be adequately marked, one of them being from Point Roberts, on Juan de Fuca Strait, eastward for a distance of about 41 miles, and the other being from Similkameen River, across the northern boundary of what was formerly the Colville Indian Reservation, to the Columbia River, a distance of about 91 miles; the eastern part of this latter portion, however, is not so well marked as the western part.

The portions which are inadequately marked—in fact, not marked at all—comprise intervals as follows:

Portions of international boundary west of the summit of the Rocky Mountains and the Mooyie Trail monument which are not marked.

	Miles (approximate).
West slope of Cascade Mountains	16
Across summit of Cascade Mountains to Pasayten River	54
Pasayten River to one hundred and twentieth meridian	24
One hundred and twentieth meridian to Similkameen River	15
Columbia River to Clark Fork	10
Clark Fork to Kootenai Mountain	11
Kootenai Mountain to Kootenai River	28
Kootenai River to Mooyie Trail	15
Mooyie River to Yaak River	25
Yaak River to summit west of Kootenai River	17
Summit west of Kootenai River to Kootenai River	5
Kootenai River to summit	5
Summit to Wigwam River	14
Wigwam River to Flathead River	14
Flathead River to Kishemeen Creek	4
Kishemeen Creek to summit of Rocky Mountains	13

There is no question as to the desirability of properly marking the boundary line, although it is true that the unmarked portions are in a rough, mountainous, and unsettled section, and the expense and labor connected with making the necessary resurveys and placing monuments would be large.

When the boundary line between Idaho and Montana was run northward to the international boundary, it was not possible to locate its terminal point as satisfactorily as might have been desired, because of the fact that there was no monument on the international boundary within a reasonable distance with which a connection could be made. The same is true of the boundary line between Washington and Idaho, and also of a guide meridian run by the Geological Survey northward from the thirteenth standard parallel in Idaho. The Washington Forest Reserve, the Priest River Forest Reserve, and the Flathead Forest Reserve abut against this boundary, and in making the topographic survey of these reserves, as well as in projecting the public-land lines northward, it is very important that there should be well-defined monuments to which these surveys can [illegible] connected. There are, of course, many other apparent reasons

SUMMIT OF BITTERROOT MOUNTAINS, SHOWING PACK TRAIN LOADED WITH SECTIONS OF GRANITE MONUMENT.

why the international boundary should be permanently and conspicuously marked, but special reference is made to those mentioned, for they have a bearing on the work of the Geological Survey.

As the instructions relating to the Idaho-Montana boundary line provided for a connection by triangulation or other methods with a monument on the international boundary, inquiry was made at the State Department for information on the subject and permission was granted to examine the records of the Northwest Boundary Survey. A visit was made to the manuscript room of the Department, and several lists of geographical positions were found. As these positions have not been published heretofore, two lists are given below. The second list gives geographical positions, and is signed by officers of the British and American commissions.

Extracts from State Department records of United States Northwest Boundary Survey.

[In lead-colored chest in manuscript room.]

Camp Columbia	[1]117° 37′ 33″.9 on brink of hill, west bank of river.
	[1]117° 37′ 05″.2 near east bank of river.
Camp Kootenay West	116° 35′ 44″.9 on side of mountain, west side of valley.
	116° 31′ 05″.9 on brow of first hill, right bank of river.
Camp Mooyie	116° 12′ 22″.3 on side of mountain, west side of valley.
	116° 11′ 54″.5 on plateau above creek. Position approximate.
	116° 11′ 25″.6 on left bank of creek close to water.
	116° 11′ 24″ on high bluff left bank. Position approximate.
Camp Kootenay East	115° 16′ 01″.4 on east bank of ravine beyond which the mountains rise.
	115° 11′ 11″.2 on right bank of Kootenay River.
	115° 10′ 11″.6 on second plateau, left bank of river.
	115° 03′ 28″.7 at foot of mountain, left bank small creek. (N. B.—This station was moved from its position as placed by the United States surveyors by the British surveyors. Description is of the new position.)

	Lat. N.			Long. W. Gr.		
	°	′	″	°	′	″
Camp Columbia	48	59	50.4	117	37	41.8
Fort Shepherd Station	49	00	00.0	117	37	19.4
Junction of Salmon River with Clarks Fork	49	01	32.4	117	23	24.5
Pend O'Reille Station	49	00	03.5	117	21	52.9
Kootenay Mountain Station	49	00	12.8	117	10	48.4
Triangulation pole	48	58	48.0	117	00	33.1
Sinyakuateen depot	48	09	23.8	116	43	42.9
Camp Kootenay West	48	59	55.1	116	31	16.2
Junction of trails near Acklewcache	48	54	21.4	116	22	02.1
Mooyie Trail monument	49	00	01.3	116	14	59.2
Camp Mooyie	49	01	26.0	116	12	40.5
Yaht Station	48	59	55.4	115	38	51.0

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[1] Monuments changed by English commission after verification.

From the foregoing list it appeared that the Mooyie Trail monument was the point on the international boundary nearest the Idaho-Montana boundary line, and Mr. Perkins was instructed to make a search for it. The monument is about 32 miles from Bonners Ferry, Idaho, and is easily reached by the new Wild Horse trail. It is on the west side of and near the trail between Round Meadows hay ranch, or Walters Prairie, and Mooyie River, and about 5 miles from the former. It is about a half mile beyond a section of the trail which for a distance of about one-fourth mile is filled with loose rock. As the monument is approached the trail passes through a heavy growth of timber and underbrush. The monument consists of a large pile of partly angular rocks, now knocked down by fallen trees. Originally, the trees in the immediate vicinity of the monument were cut down.

It will be observed that the latitude for the Mooyie Trail monument given in the list signed by the officers of the United States and British commissions is 49° 00′ 01″.3, or 1″.3 (about 132 feet) north of the parallel constituting the international boundary, and it was supposed that the point marked by the monument was in that latitude, and therefore not exactly on the international boundary. During the field season of 1898 the triangulation was extended so as to locate this monument, and its position deduced from the Spokane base is as follows: Latitude, 49° 00′ 01″.51; longitude, 116° 14′ 19″.48.

The check in latitude, 21 feet, was considered very satisfactory, and even the discrepancy in longitude, about 2,647 feet, was not more than might be expected, considering the lack of telegraphic facilities at the time of the Northwest Boundary survey. The point determined as the true one for the intersection of the international boundary and the Idaho-Montana boundary line was located with reference to the Mooyie Trail monument, so that there need be no large discrepancy, except that due to station error, when the international boundary is ultimately traced and marked, it being assumed that the work already done by the Northwest Boundary survey will be accepted and utilized.

The distance from the point on the Idaho-Montana boundary line at the crest of the Bitterroot Mountains to the international boundary, used in placing the initial monument, was computed as follows, the constants being taken from United States Coast and Geodetic Survey Report, 1884, Appendix No. 6:

	Latitude.		
	°	′	″
Transit station, crest of Bitterroot Mountains	47	58	35.56
International parallel	49	0	0.00
Difference	1	01	24.44

1° =69.097 miles=364,832 feet.
1′ =1,853.16 meters.
log. 1″ =30.886 meters, 1.489762
log. 24″.44 1.388101
log. 754.85 meters = 2.877863
1,853.16
log. 2,608.01 meters, 3.416309
log. meters to feet, 0.515984
log. 8,554 feet = 3.932293
364,832
373,386 feet.
Correction[1] = +21
373,407 feet, total distance.

FINANCIAL STATEMENT.

A financial statement is presented below showing how the amount appropriated for the survey of the boundary line was expended. As already mentioned, however, this amount does not represent the entire cost of the work, for the greater portion of the animals and outfit were transferred from other localities, where they had been used by parties of the Geological Survey working under other appropriations. Further, it was possible to use a portion of the triangulation done in connection with the forest surveys, and the expenses of the party while engaged in sketching topography were charged in part against the appropriation for topographic surveys. No portion of the salary of the geographer in charge of the work was paid from the appropriation for the boundary line, nor were any office salaries charged against it. But for this material assistance, which did not in any way detract from other work, the cost of the boundary survey would probably have been increased more than twofold. On the other hand, a large portion of what was accomplished in connection with the boundary line can be utilized in other directions. The appropriation of $7,650 was originally made for expenditure during the fiscal year ending June 30, 1898. The unexpended balance on that date was, however, made available by act of Congress for the year ending June 30, 1899, and again, in a similar manner, the unexpended balance at the latter date was reappropriated for the fiscal year ending June 30, 1900. The appropriation became practically exhausted in October, 1899.

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[1] By triangulation connection with Mooyie Trail monument, the position of this monument is 0.″21 farther north than as given by the international boundary survey, hence to reduce all positions to the international-boundary survey system, latitudes of United States Geological Survey triangulation are decreased 0″.21, or its equivalent, 21 feet, the distance from initial point on Bitterroot Mountains to forty-ninth parallel being increased 21 feet.

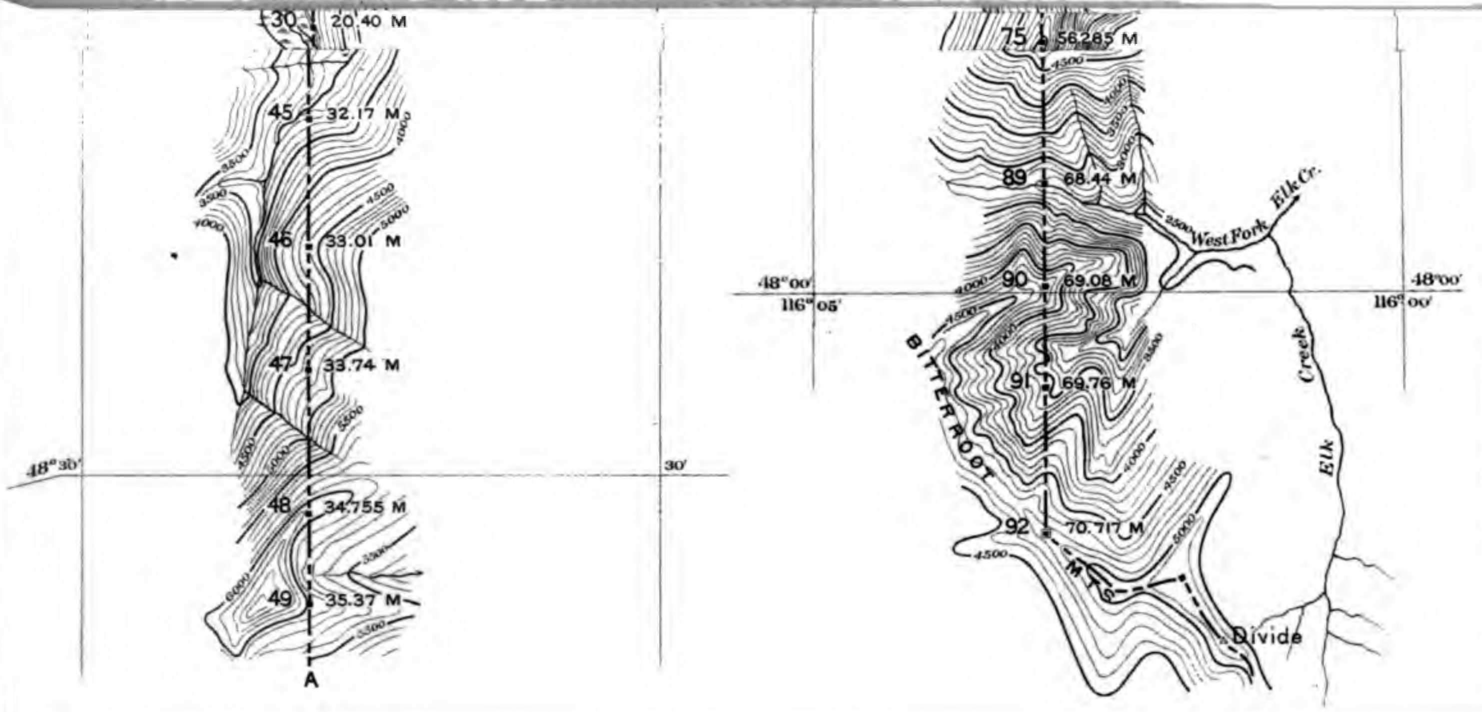
Financial statement relating to appropriation for survey of boundary line between Idaho and Montana.

Date.	To whom paid.	For what paid.	Amount.
1897.			
June 30	E. T. Perkins, jr., topographer	Services, June 8-30	$101.10
July 3	....do	Traveling expenses	60.75
10	G. M. Metzler	Shoeing, etc	23.00
10	Isaac I. Lewis	Tollage supplies, etc	13.57
10	Lindsay & Merriam	Subsistence supplies	61.04
10	F. O. Berg	Tentage	19.90
10	Holly, Mason, Marks & Co	Hardware	58.50
10	Spokane Dry Goods Co	Saddles, blankets, and pack covers	43.46
12	Mark E. Davis	Saddlery, etc	28.50
12	S. H. Rush	Saddlery, etc	38.75
15	E. T. Perkins, jr	Field expenses	160.56
24	E. C. Murphy	One mule	80.00
29	E. T. Perkins, jr	Field expenses	78.05
31	Pay roll of employees	Services, July, 1897	241.60
Aug. 7	C. P. Willis	One horse	15.00
17	Exchange National Bank	Horses and mules	143.10
17	E. T. Perkins, jr	Field expenses	116.12
19	United States Express Co	Freight	46.57
25	Chicago and Northwestern Railway Co.	Transportation	12.50
31	Pay roll of employees	Services, August, 1897	241.00
Sept. 4	E. T. Perkins, jr	Field expenses	129.65
4	S. H. Rush	Harness	34.50
8	Richard Smith	Wagon	75.00
11	Oregon Short Line R. R	Transportation	50.69
28	E. T. Perkins, jr	Field expenses	50.65
30	Pay roll of employees	Services, September, 1897	213.89
Oct. 11	H. Baumgarten	Stamps	.30
14	John O'Connell	Transportation	20.00
18	Young & Sons	Transit	255.00
30	E. T. Perkins, jr	Field expenses	192.56
31	Pay roll of employees	Services, October, 1897	236.60
Nov. 11	Northern Pacific Railway Co	Transportation	4.25
15	E. T. Perkins, jr	Field expenses	196.44
Dec. 4	Pay roll of employees	Services, November, 1897	193.97
8	Schoellhorn-Albrecht Machine Co	Iron monuments	208.33
20	E. T. Perkins, jr	Field expenses	108.45
1898.			
Jan. 13	Northwestern Storage and Transportation Co.	Storage	4.50
17	....do	....do	2.85
Feb. 10	P. Morrison	Pasturage	36.50
12	H. L. Schermerhorn	Storage	4.50
Mar. 12	....do	....do	4.50
15	Western Union Telegraph Co	Telegrams	3.84
15	....do	....do	.80
31	P. Morrison	Pasturage	15.00
Apr. 8	H. Louis Schermerhorn	Storage	4.50
14	P. Morrison	Pasturage	15.00
May 10	Northwestern Storage and Transportation Co.	Storage	4.50
10	P. Morrison	Pasturage	15.00

Financial statement relating to appropriation for survey of boundary line between Idaho and Montana—Continued.

Date.	To whom paid.	For what paid.	Amount.
1898.			
June 8	P. Morrison	Pasturage	$15.00
11	H. Louis Schermerhorn	Storage	4.50
July 13	Lindsay & Hall	Subsistence supplies	59.45
Aug. 3	Pay roll of employees	Services, July, 1898	414.67
11	Arend & Kenward	Subsistence supplies	36.00
11	Holly, Mason, Marks & Co	Hardware	10.90
11	P. Morrison	Pasturage	15.00
17	D. L. Reaburn	Field expenses	59.08
Sept. 13	....do	....do	35.30
13	R. U. Goode	....do	23.15
13	Gordon Daugherty	Subsistence supplies	49.41
13	Pay roll of employees	Services, August, 1898	473.06
13	Giles & Peat	Stone monuments	58.00
13	D. L. Reaburn	Field expenses	43.77
21	Oregon Railroad and Navigation Co	Transportation	16.65
21	F. B. Collow	Subsistence supplies	77.54
21	Northern Pacific Railway Co	Transportation	32.10
Oct. 11	Pay roll of employees	Services, September, 1898	465.00
14	W. E. R. Brewster	Subsistence supplies	79.80
Nov. 7	Pay roll of employees	Services, October, 1898	425.00
7	D. L. Reaburn	Field expenses	189.68
16	....do	....do	161.12
26	....do	....do	137.17
26	Northern Pacific Railway Co	Transportation	9.90
Oct. 19	Southern Pacific Co	....do	88.00
19	....do	....do	17.05
Dec. 12	S. W. Johnson	Pasturage	13.65
1899.			
Jan. 17	Great Northern Railway Co	Transportation	15.15
Feb. 16	United States Express Co	Expressage	10.65
Mar. 20	Western Union Telegraph Co	Telegrams	.90
20	....do	....do	.48
June 30	Pay roll of employees	Services, June, 1899	316.67
July 17	D. L. Reaburn	Field expenses	213.75
31	Pay roll of employees	Services, July, 1899	352.10
Aug. 8	E. J. Brooks & Co	Steel dies and letters	2.12
Sept. 12	D. L. Reaburn	Field expenses	152.96
16	....do	....do	21.40
	Total		7,649.50
	Amount appropriated		7,650.00
	Balance		.50

BOUNDARY BETWEEN IDAHO AND MONTANA



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1900

UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

BOUNDARIES
OF
THE UNITED STATES
AND OF THE
SEVERAL STATES AND TERRITORIES
WITH AN OUTLINE OF THE
HISTORY OF ALL IMPORTANT CHANGES OF TERRITORY

(SECOND EDITION)

BY

HENRY GANNETT

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ILLUSTRATIONS.

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DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., April 14, 1900.

SIR: I have the honor to submit herewith a sketch of the boundaries of the United States, the several States, and the Territories, as defined by treaty, charter, or statute. Besides giving the present status of these boundaries I have endeavored to present an outline of the history of all important changes of territory, with the laws appertaining thereto.

The work constitutes a revised and enlarged edition of Bulletin No. 13, published in 1885.

Very respectfully,
HENRY GANNETT,
Geographer.

Hon. C. D. WALCOTT,
Director United States Geological Survey.

BOUNDARIES OF THE UNITED STATES AND OF THE SEVERAL STATES AND TERRITORIES, WITH AN OUTLINE OF THE HISTORY OF ALL IMPORTANT CHANGES OF TERRITORY.

By HENRY GANNETT.

CHAPTER I.

BOUNDARIES OF THE UNITED STATES, AND ADDITIONS TO ITS TERRITORY.

BOUNDARIES OF THE UNITED STATES.

PROVISIONAL TREATY WITH GREAT BRITAIN.

The original limits of the United States were first definitely laid down in the provisional treaty made with Great Britain in 1782. The second article of that treaty defines its boundaries as follows:

> From the northwest angle of Nova Scotia, viz, that angle which is formed by a line drawn due north from the source of St. Croix river to the highlands; along the Highlands which divide those rivers that empty themselves into the river St. Lawrence, from those which fall into the Atlantic Ocean, to the northwesternmost head of Connecticut River; thence down along the middle of that river to the forty-fifth degree of north latitude; from thence, by a line due west on said latitude until it strikes the river Iroquois or Cataraquy (St. Lawrence); thence along the middle of said river into Lake Ontario, through the middle of said lake until it strikes the communication by water between that lake and Lake Erie; thence along the middle of said communication into Lake Erie, through the middle of said lake until it arrives at the water communication between that lake and Lake Huron; thence along the middle of said water communication into the Lake Huron; thence through the middle of said lake to the water communication between that lake and Lake Superior; thence through Lake Superior northward of the Isles Royal and Phelippeaux to the Long Lake; thence through the middle of said Long Lake, and the water communication between it and the Lake of the Woods, to the said Lake of the Woods; thence through the said lake to the most northwestern point thereof, and from thence on a due west course to the river Mississippi; thence by a line to be drawn along the middle of the said river Mississippi until it shall intersect the northernmost part of the thirty-first degree of north latitude. South by a line to be drawn due east from the determination of the line last mentioned, in the latitude of thirty-one degrees north of the Equator, to the middle of the river Apalachicola or Catahouche; thence along the middle thereof to its junction with the Flint River; thence strait to the head of St. Mary's River; and thence down along the middle of St. Mary's River to the Atlantic Ocean. East by a line to be drawn along the middle of the river St. Croix, from its mouth in the Bay of Fundy to its source, and from its source directly north to the aforesaid highlands which divide the rivers that fall into the Atlantic Ocean from those which fall into the river St. Lawrence; comprehending all islands within twenty leagues of any part of the shores of the United States, and lying between lines to be drawn due east from the points where the aforesaid boundaries between Nova Scotia on the one part and East Florida on the other, shall respectively touch the Bay of Fundy and the Atlantic Ocean; excepting such islands as now are, or heretofore have been within the limits of the said province of Nova Scotia.

TREATY WITH SPAIN OF 1798.

The boundary between the United States and the Spanish Possessions, known as the Floridas, is reaffirmed in the treaty between the United States and Spain, made in 1795, in the following terms:

> The southern boundary of the United States, which divides their territory from the Spanish colonies of East and West Florida, shall be designated by a line beginning on the river Mississippi, at the northernmost part of the thirty-first degree of latitude north of the equator, which from thence shall be drawn due east to the middle of the river Apalachicola or Catahouche, thence along the middle thereof to its junction with the Flint; thence straight to the head of St. Mary's River, and thence down the middle thereof to the Atlantic Ocean.

DEFINITIVE TREATY WITH GREAT BRITAIN.

The definitive treaty of peace with Great Britain, concluded September 3, 1783, defines the boundaries of the United States in terms similar to those of the provisional treaty.

The northern boundary became at once a fruitful source of dissension between the two countries. From the time of the conclusion of peace almost to the present day this line has been the subject of a series of treaties, commissions, and surveys for the purpose of interpreting its terms.

The following is in outline a history of the settlement of this boundary:

TREATY OF LONDON, 1794.

The fourth article of the treaty of London, signed November 19, 1794, provided that—

> Whereas it is uncertain whether the river Mississippi extends so far to the northward as to be intersected by a line to be drawn due west from the Lake of the Woods in the manner mentioned in the treaty of peace between His Majesty and the United States, etc., the two parties will proceed by amicable negotiation to regulate the boundary line in that quarter.

This matter was not settled, however, until 1818.

The fifth article of the same treaty makes provision for settling another doubtful point, as follows:

> Whereas doubts have arisen what river was truly intended under the name of the river St. Croix mentioned in the said treaty of peace, and forming a part of the boundary therein described, that question shall be referred to the final decision of commissions to be appointed in the following manner, viz.

Here follow provisions that His Majesty and the President of the United States should each appoint a commissioner, and that these two commissioners should agree on a third, or, they failing to agree on the third, he was to be chosen by lot in their presence.

Which was the true St. Croix River had been a matter of controversy between the governments of Massachusetts and Nova Scotia since the year 1764.

The commissioners appointed under the foregoing provisions decided, on the 25th of October, 1798, the river called Schoodiac and the northern branch thereof (called Cheputnaticook) to be the true river St. Croix, and that its source was at the northernmost headspring of the northern branch aforesaid. A monument was erected at that spot under the direction of the commissioners. (See Memoirs of Northeastern Boundary, Gallatin, pages 7, 8.)

TREATY OF GHENT.

By the treaty of peace concluded at Ghent, December 24, 1814, it was agreed to provide for a final adjustment of the boundaries described in the treaty of 1783, which had not yet been ascertained and determined, embracing certain islands in the Bay of Fundy and the whole of the boundary line from the source of the river St Croix to the most northwestern point of the Lake of the Woods.

By article 4 provision was made for a board of commissioners to settle the title to several islands in the Bay of Passamaquoddy, which is a part of the Bay of Fundy, and the island of Grand Menan in the said Bay of Fundy.

The fifth article made provision for a board of commissioners to settle the boundary from the source of the river St. Croix northward to the highland which divides those waters that empty themselves into the river St. Lawrence from those which fall into the Atlantic Ocean, thence along said highlands to the northwesternmost head of Connecticut River, thence down along the middle of that river to the forty-fifth degree of north latitude, thence due west on said latitude until it strikes the river Iroquois or Cataraquy (St. Lawrence).

The sixth and seventh articles provided for commissioners to continue the line to the northwestern point of the Lake of the Woods.

(For further details see treaty, Statutes at Large, vol. 8, pages 220–2.)

It was provided by this treaty that in case any of the boards of commissioners were unable to agree, they should make separately or jointly a report or reports to their respective Governments stating the points on which they differed, the grounds on which they based their respective opinions, etc.

These reports were to be referred to some friendly sovereign or state for arbitration.

The first and third boards of commissioners above mentioned came to an agreement, and those portions of the boundary were thus finally settled; but the commission appointed under the fifth article, after sitting nearly five years, could not agree on any of the matters referred to them, nor even on a general map of the country exhibiting the boundaries respectively claimed by each party. They accordingly made separate reports to their Governments, stating the points on which they differed and the grounds upon which their respective opinions had been formed.

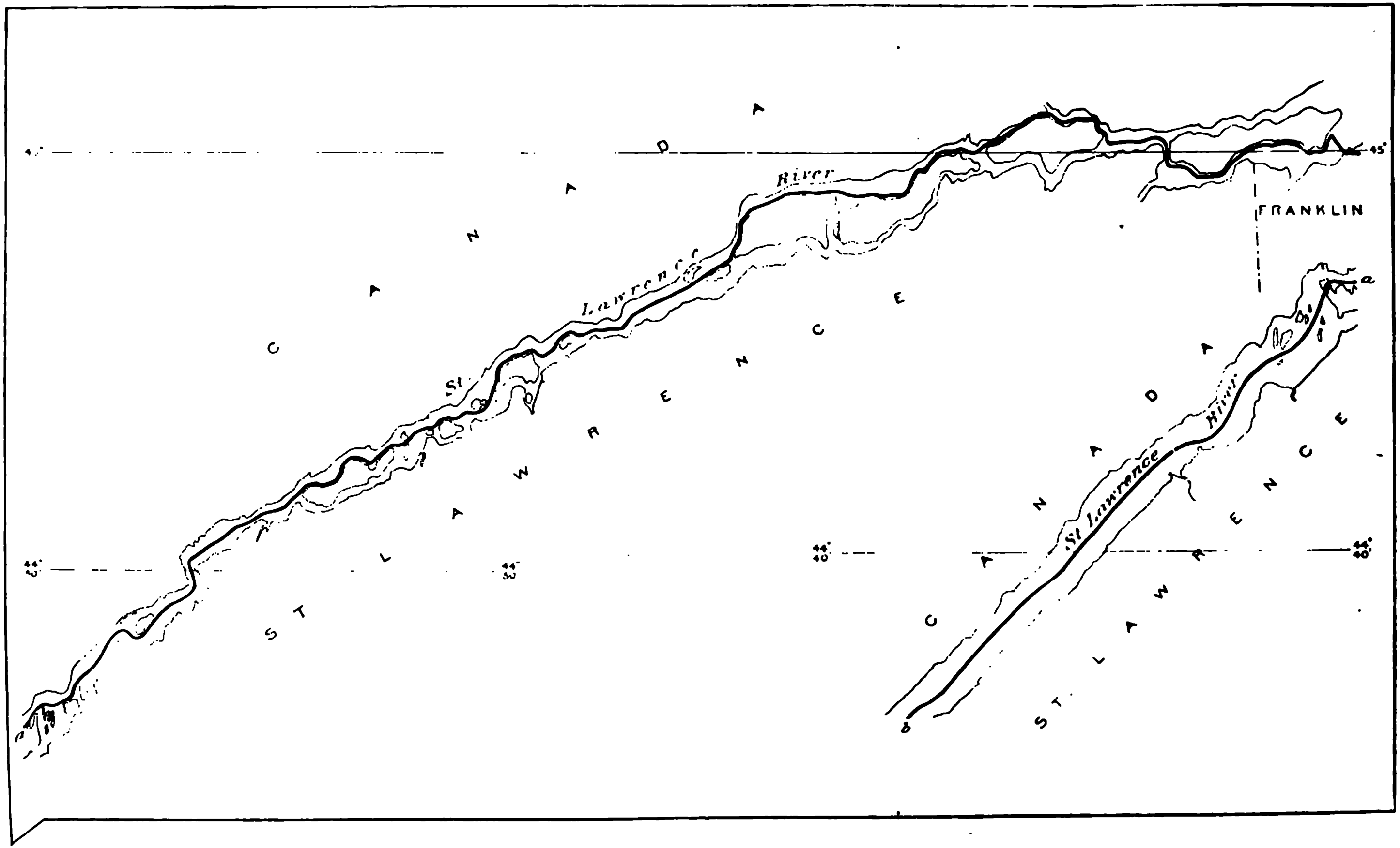
The first of these commissions awarded Moore, Dudley, and Frederick Islands to the United States, and all other islands in Passamaquoddy Bay, and the island of Grand Menan, to Great Britain.

The following is the text of the report of the third of these commissions which had under consideration that portion of the northern boundary between the point where the forty-fifth parallel of north latitude strikes the St. Lawrence and the point where the boundary reaches Lake Superior:

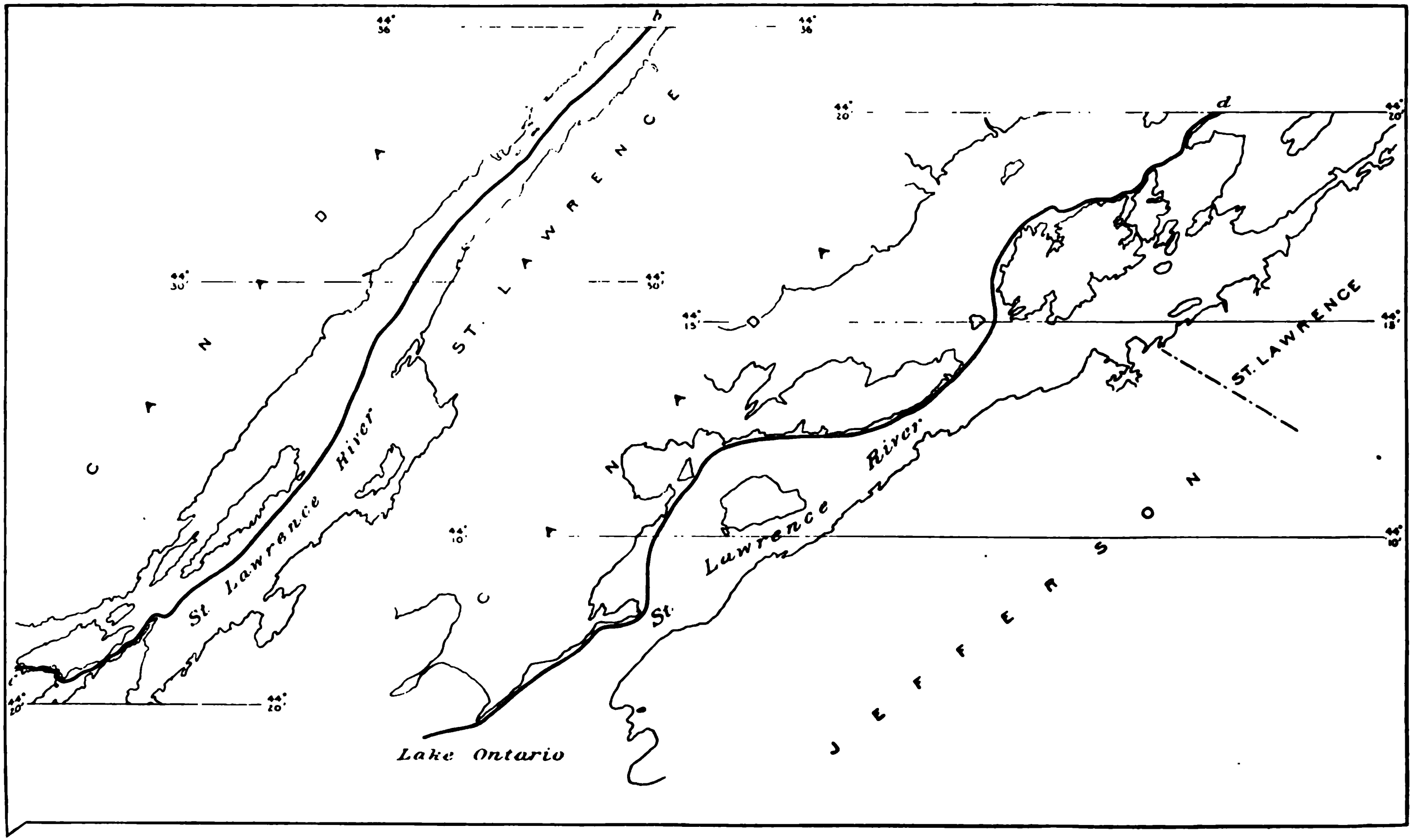
Decision of the commissioners under the sixth article of the treaty of Ghent, done at Utica, in the State of New York, 18th June, 1822.

We do decide and declare that the following-described line (which is more clearly indicated on a series of maps accompanying this report, exhibiting correct surveys and delineations of all the rivers, lakes, water communications, and islands embraced by the sixth article of the treaty of Ghent, by a black line shaded on the British side with red and on the American side with blue; and each sheet of which series of maps is identified by a certificate, subscribed by the commissioners, and by the two principal surveyors employed by them) is the true boundary intended by the two beforementioned treaties, that is to say:

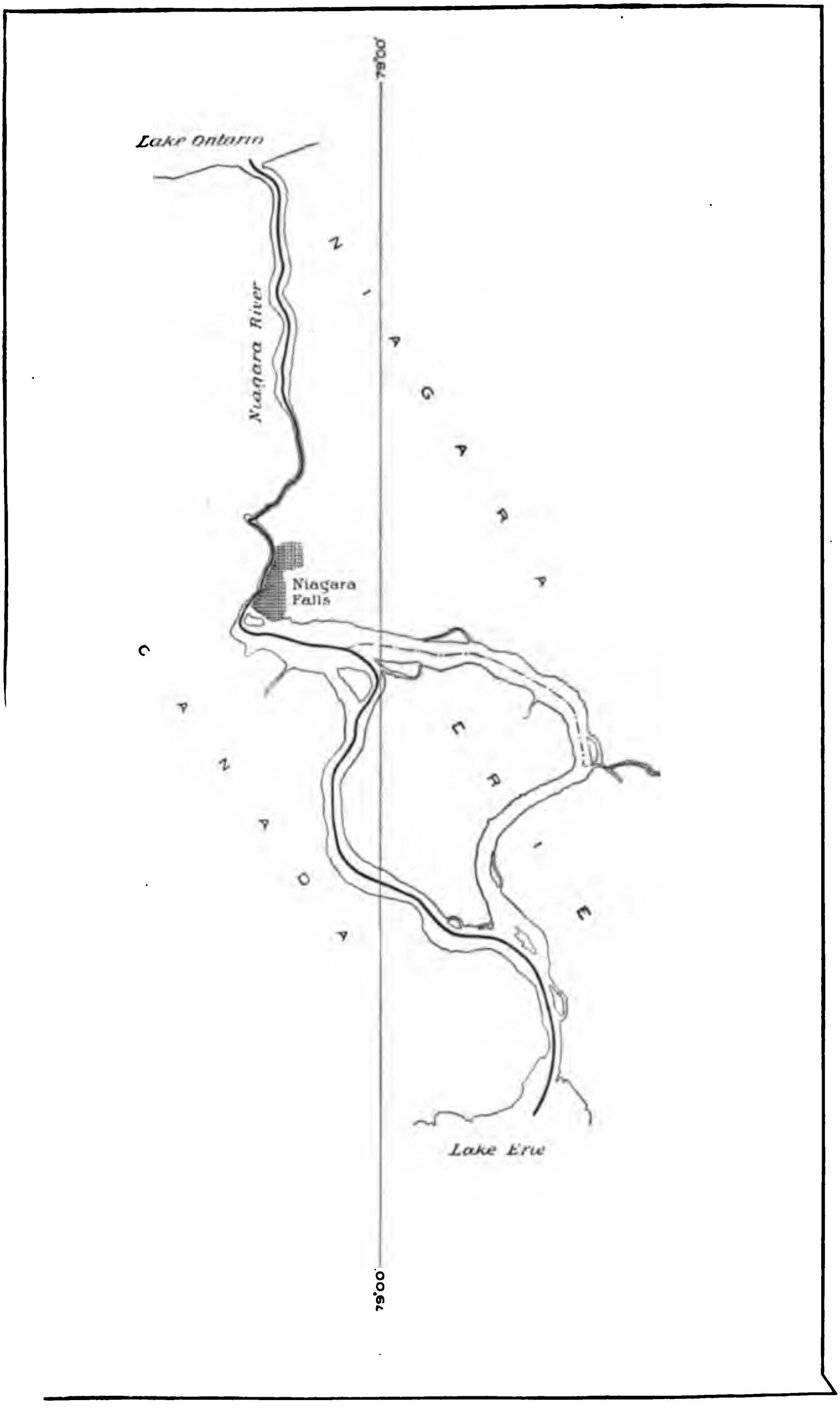
Beginning at a stone monument, erected by Andrew Ellicot, esq., in the year 1817, on the south bank or shore of the said river Iroquois, or Cataraqui (now called the St. Lawrence), which monument bears south 74° 45′ west, and is 1,840 yards distant from the stone church in the Indian village of St. Regis, and indicates the point at which the forty-fifth parallel of north latitude strikes the said river; thence running north 35° 45′ west into the river, on a line at right angles with the southern shore, to a point 100 yards south of the opposite island, called Cornwall Island; thence turning westerly and passing around the southern and western sides of said island, keeping 100 yards distant therefrom, and following the curvatures of its shores, to a point opposite to the northwest corner or angle of said island; thence to and along the middle of the main river until it approaches the eastern extremity of Barnhart's Island; thence northerly along the channel which divides the last-mentioned island from the Canada shore, keeping 100 yards distant from the island, until it approaches Sheik's Island; thence along the middle of the strait which divides Barnhart's and Sheik's Islands to the channel called the Long Sault, which separates the two last-mentioned islands from the lower Long Sault Island; thence westerly (crossing the center of the last-mentioned channel) until it approaches within 100 yards of the north shore of the Lower Sault Island; thence up the north branch of the river, keeping to the north of and near the Lower Sault Island, and also north of and near the Upper Sault, sometimes called Baxter's Island, and south of the two small islands marked on the map A and B, to the western extremity of the Upper Sault or Baxter's Island; thence, passing between the two islands called the Cats, to the middle of the river above; thence along the middle of the river, keeping to the north of the small islands marked C and D, and north also of Chrystler's Island, and of the small island next above it, marked E, until it approaches the northeast angle of Goose Neck Island; thence along the passage which divides the last-mentioned island fro mthe Canada shore, keeping 100 yards from the island to the upper end of the same; thence south of and near the two small islands called the Nut Islands; thence north of and near the island marked F, and also of the island called Dry or Smuggler's Island; thence passing between the islands marked G and H to the north of the island called Isle au Rapid Platt; thence along the north side of the last-mentioned island, keeping 100 yards from the shore, to the upper end thereof; thence along the middle of the river, keeping to the south of and near the islands called Coussin (or Tussin) and Presque Isle; thence up the river, keeping north of and near the several Gallop Isles numbered on the map 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10, and also of Tick, Tibbits, and Chimney Islands, and south of and near the Gallop Isles numbered 11, 12, and 13, and also of Duck, Drummond, and Sheep Islands; thence along the middle of the river, passing north of island No. 14, south of 15 and 16, north of 17, south of 18, 19, 20, 21, 22, 23, 24, 25, and 28, and north of 26 and 27; thence along the middle of the river, north of Gull Island and of the islands Nos. 29, 32, 33, 34, 35, Bluff Island, and Nos. 39, 44, and 45, and to the south of Nos. 30, 31, 36, Grenadier Island, and Nos. 37, 38, 40, 41, 42, 43, 46, 47, and 48, until it approaches the east end of Well's Island; thence to the north of Well's Island, and along the strait which divides it



BOUNDARY BETWEEN NEW YORK AND CANADA IN ST. LAWRENCE RIVER.



BOUNDARY BETWEEN NEW YORK AND CANADA IN ST. LAWRENCE RIVER.



BOUNDARY BETWEEN NEW YORK AND CANADA IN NIAGARA RIVER.

from Rowe's Island, keeping to the north of the small islands Nos. 51, 52, 54, 58, 59, and 61, and to the south of the small islands numbered and marked 49, 50, 53, 55, 57, 60, and H, until it approaches the northeast point of Grindstone Island; thence to the north of Grindstone Island, and keeping to the north also of the small islands Nos. 63, 65, 67, 68, 70, 72, 73, 74, 75, 76, 77, and 78, and to the south of Nos. 62, 64, 66, 69, and 71, until it approaches the southern point of Hickory Island; thence passing to the south of Hickory Island and of the two small islands lying near its southern extremity, numbered 79 and 80; thence to the south of Grand or Long Island, keeping near its southern shore, and passing to the north of Carlton Island, until it arrives opposite to the southwestern point of said Grand Island, in Lake Ontario; thence, passing to the north of Grenadier, Fox, Stony, and the Gallop Islands, in Lake Ontario, and to the south of and near the islands called the Ducks, to the middle of the said lake; thence westerly along the middle of said lake to a point opposite the mouth of the Niagara River; thence to and up the middle of the said river to the Great Falls; thence up the Falls through the point of the Horse Shoe, keeping to the west of Iris or Goat Island, and of the group of small islands at its head, and following the bends of the river so as to enter the strait between Navy and Grand Islands; thence along the middle of said strait to the head of Navy Island; thence to the west and south of and near to Grand and Beaver Islands, and to the west of Strawberry, Squaw, and Bird Islands to Lake Erie; thence southerly and westerly along the middle of Lake Erie in a direction to enter the passage immediately south of Middle Island, being one of the easternmost of the group of islands lying in the western part of said lake; thence along the said passage, proceeding to the north of Cunningham's Island, of the three Bass Islands, and of the Western Sister, and to the south of the islands called the Hen and Chickens, and of the Eastern and Middle Sisters; thence to the middle of the mouth of the Detroit River in a direction to enter the channel which divides Bois Blanc and Sugar Islands; thence up the said channel to the west of Bois Blanc Island, and to the east of Sugar, Fox, and Stony Islands, until it approaches Fighting or Great Turkey Island; thence along the western side and near the shore of said last-mentioned island to the middle of the river above the same; thence along the middle of said river, keeping to the southeast of and near Hog Island, and to the northwest of and near the island Isle à la Pêche, to Lake Saint Clair; thence through the middle of said lake in a direction to enter that mouth or channel of the river St. Clair, which is usually denominated the Old Ship Channel; thence along the middle of said channel, between Squirrel Island on the southeast and Herson's Island on the northwest, to the upper end of the last-mentioned island, which is nearly opposite to Point au Chênes, on the American shore; thence along the middle of the river Saint Clair, keeping to the west of and near the islands called Belle Rivière Isle and the Isle aux Cerfs, to Lake Huron; thence through the middle of Lake Huron in a direction to enter the strait or passage between Drummond's Island on the west and the Little Manitou Island on the east; thence through the middle of the passage which divides the two last-mentioned islands; thence, turning northerly and westerly, around the eastern and northern shores of Drummond's Island, and proceeding in a direction to enter the passage between the island of Saint Joseph's and the American shore, passing to the north of the intermediate islands Nos. 61, 11, 10, 12, 9, 6, 4, and 2, and to the south of those numbered 15, 13, 5, and 1; thence up the said last-mentioned passage, keeping near to the island Saint Joseph's, and passing to the north and east of Isle à la Crosse and of the small islands numbered 16, 17, 18, 19, and 20, and to the south and west of those numbered 21, 22, and 23, until it strikes a line (drawn on the map with black ink and shaded on one side of the point of intersection with blue and on the other with red) passing across the river at the head of Saint Joseph's Island and at the foot of the Neebish Rapids, which line denotes the termination of the boundary directed to be run by the sixth article of the treaty of Ghent.

And the said commissioners do further decide and declare that all the islands lying in the rivers, lakes, and water communications between the before-described boundary line and the adjacent shores of Upper Canada do, and each of them does, belong to His Britannic Majesty, and that all the islands lying in the rivers, lakes, and water communications between the said boundary line and the adjacent shores of the United States or their territories do, and each of them does, belong to the United States of America, in conformity with the true intent of the second article of the said treaty of 1783, and of the sixth article of the treaty of Ghent.

In accordance with the terms of this treaty, a survey was made of the St. Lawrence and the Great Lakes, and a map prepared. This was photolithographed and published, in 29 sheets, by the United States Light-House Board, in 1891.

By the second article of the convention with Great Britain—1818—the boundary line was extended westward along the forty-ninth parallel of latitude to the "Stony" (Rocky) Mountains, while beyond these mountains the treaty provided that the country should remain open to both parties. The terms of the treaty are as follows:

ARTICLE 2. It is agreed that a line drawn from the most northwestern point of the Lake of the Woods along the forty-ninth parallel of north latitude, or if the said point shall not be in the forty-ninth parallel of north latitude, then that a line drawn from the said point due north or south, as the case may be, until the said line shall intersect the said parallel of north latitude, and from the point of such intersection due west along and with the said parallel, shall be the line of demarkation between the territories of the United States and those of His Britannic Majesty, and that the said line shall form the northern boundary of the said territories of the United States and the southern boundary of the territories of His Britannic Majesty from the Lake of the Woods to the Stony Mountains.

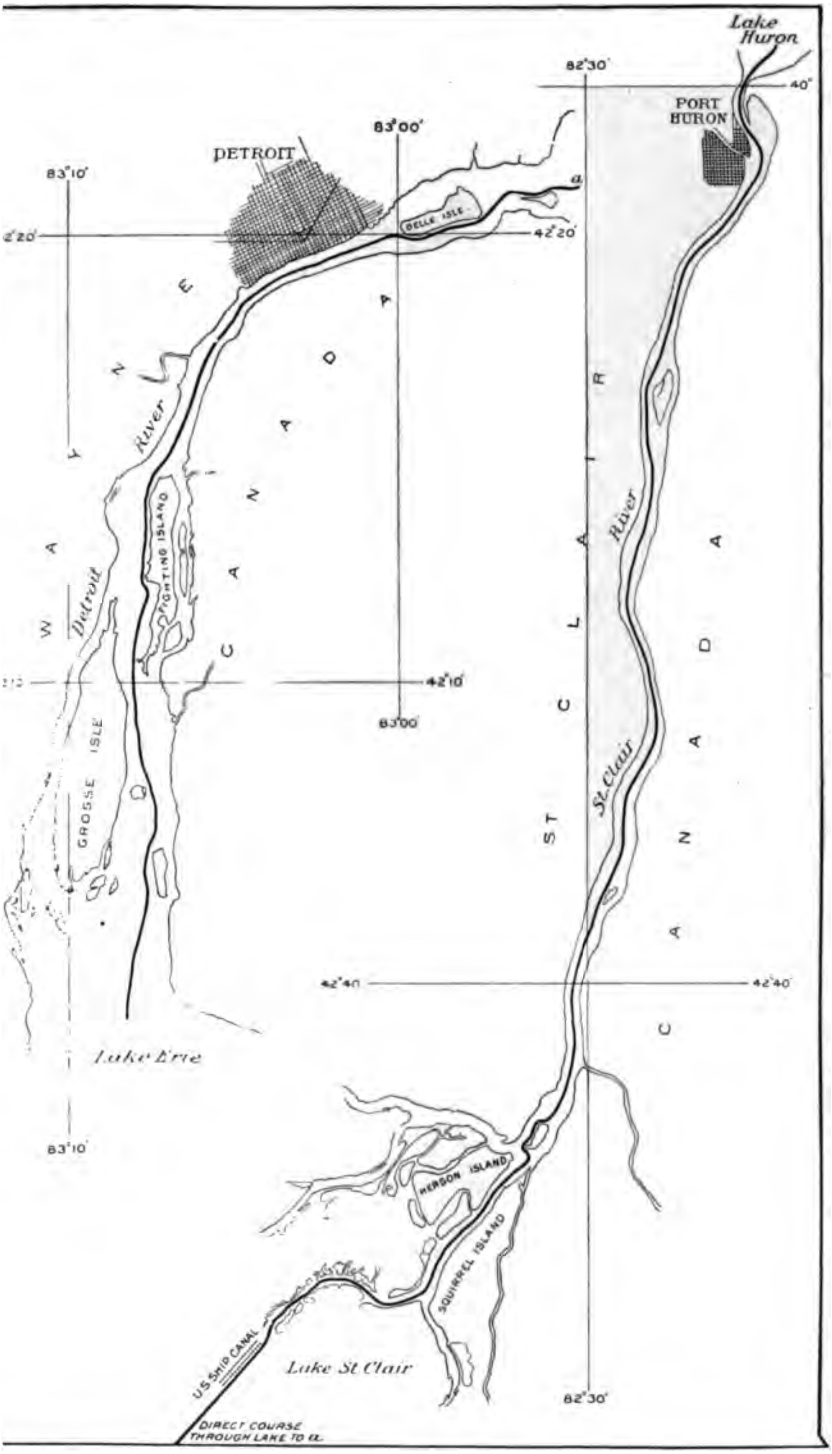
ARTICLE 3. It is agreed that any country that may be claimed by either party on the northwest coast of America, westward of the Stony Mountains, shall, together with its harbours, bays, and creeks, and the navigation of all rivers within the same, be free and open, for the term of ten years from the date of the signature of the present convention, to the vessels, citizens, and subjects of the two powers; it being well understood that this agreement is not to be construed to the prejudice of any claim which either of the two high contracting parties may have to any part of the said country, nor shall it be taken to affect the claims of any other power or state to any part of the said country; the only object of the high contracting parties in that respect being to prevent disputes and differences amongst themselves.

In 1824 negotiations were resumed between the two countries for the settlement, among other things, of the boundary west of the Rocky Mountains, but no conclusion was reached; the claim of the English Government being that the boundary line should follow the forty-ninth parallel westward to the point where this parallel strikes the great northwestern branch of Columbia River, thence down the middle of that river to the Pacific Ocean.

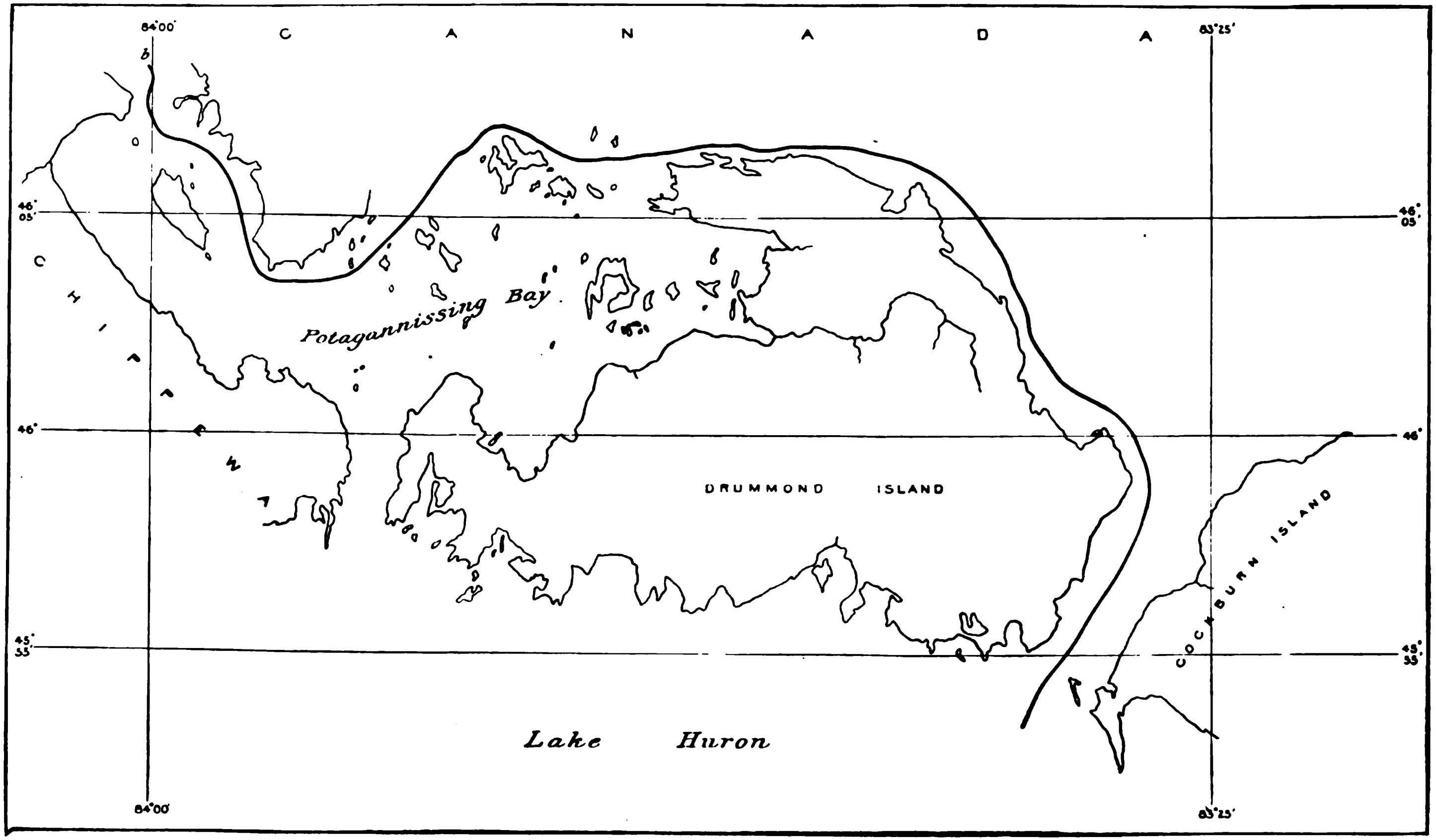
In 1826 negotiations were resumed, and several compromises were proposed by both parties, but without satisfactory results. After this the whole matter remained in abeyance until the special mission of Lord Ashburton to this country in 1842.

Meanwhile the unsettled questions regarding the northeastern boundary again came up.

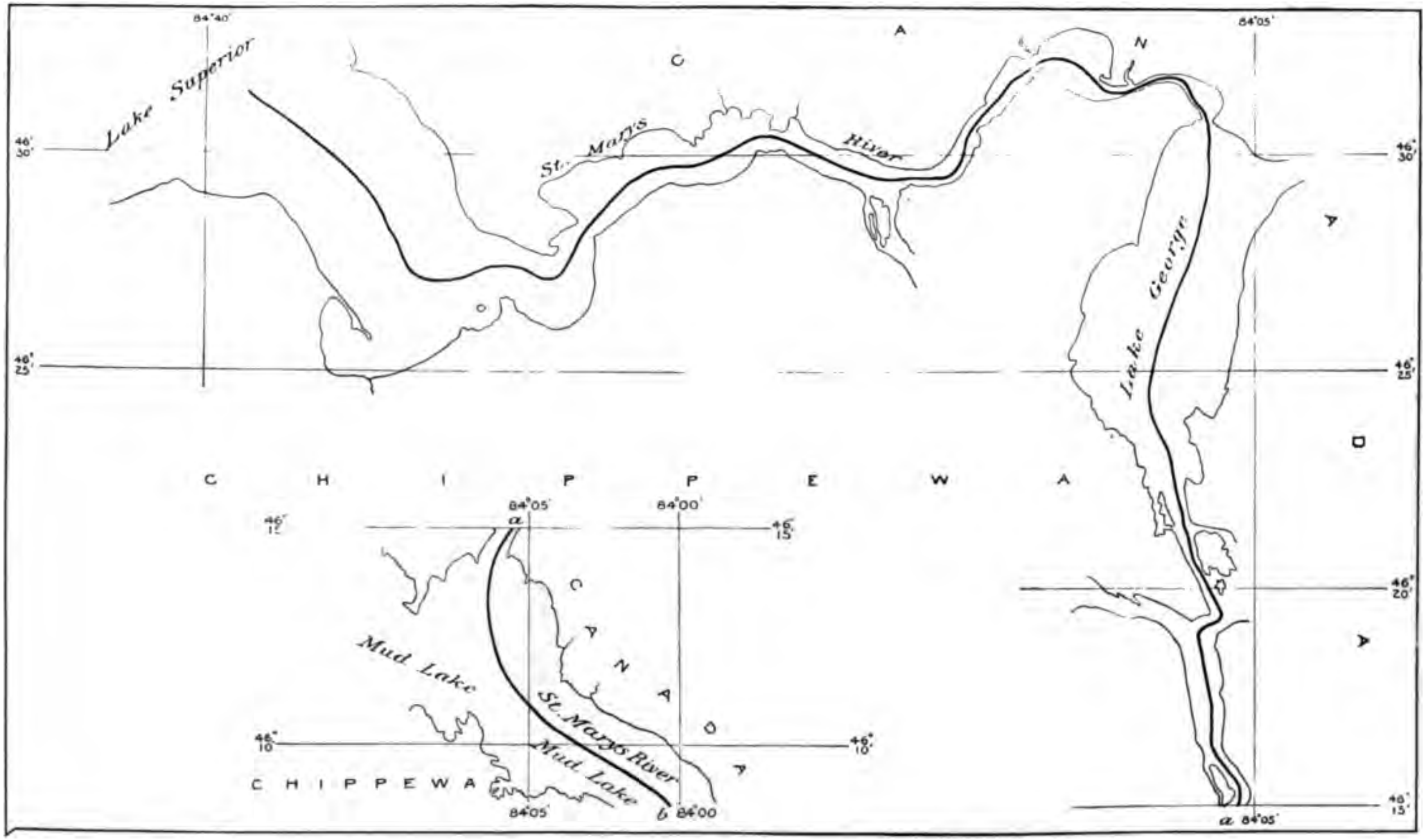
The case having reached that stage at which it became necessary to refer the points of difference to a friendly sovereign or state, the two powers found it expedient to regulate the proceedings and make provisions in relation to such reference, and on the 29th September, 1827, concluded a convention to that effect.



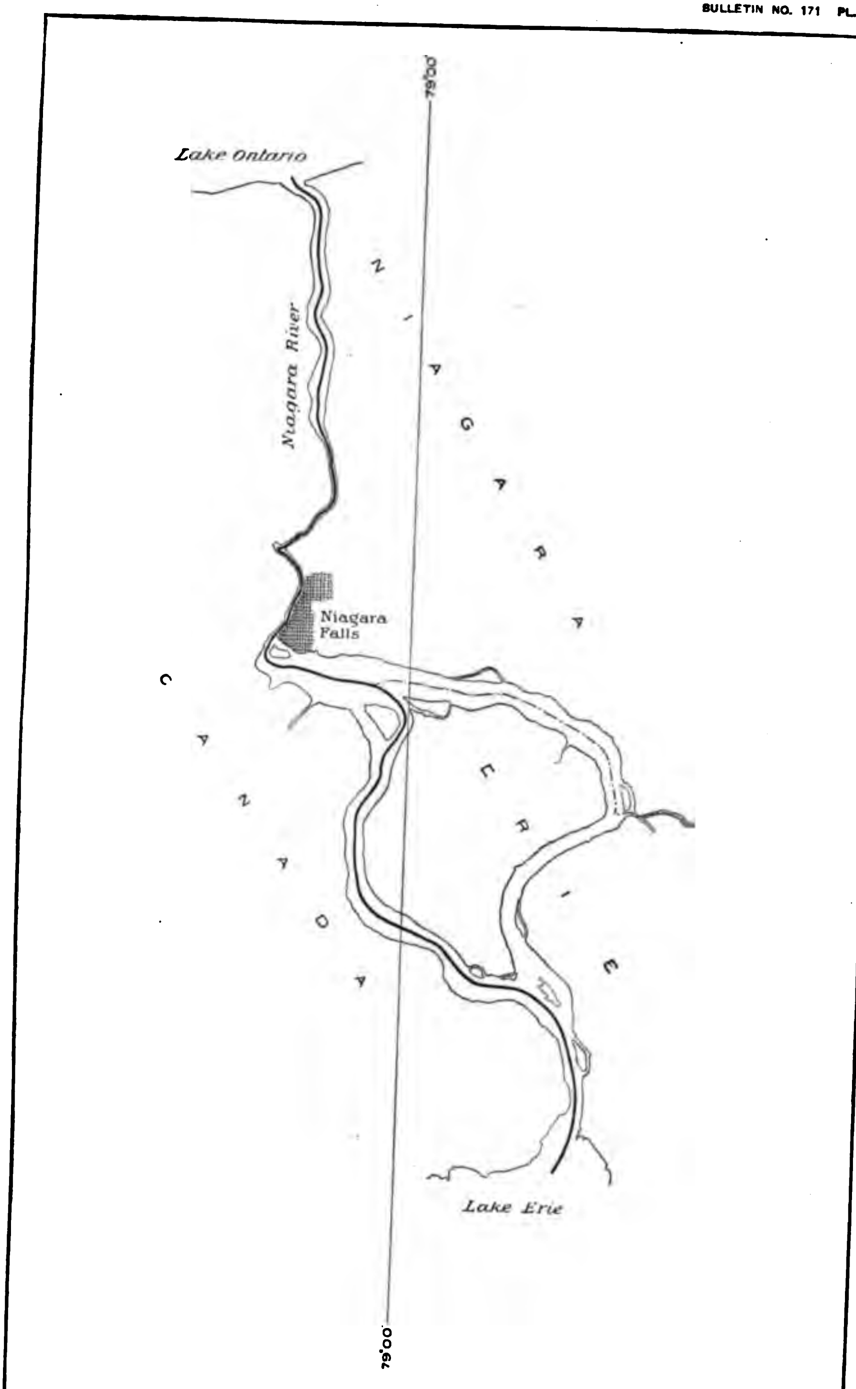
OUNDARY BETWEEN UNITED STATES AND CANADA IN ST. CLAIR AND DETROIT RIVERS.



BOUNDARY BETWEEN MICHIGAN AND CANADA THROUGH ST. MARYS RIVER.



BOUNDARY BETWEEN MICHIGAN AND CANADA THROUGH ST. MARYS RIVER.



BOUNDARY BETWEEN NEW YORK AND CANADA IN NIAGARA RIVER.

ernmost branch, which source we indicate on the Map A by the letter X, authenticated by the signature of our minister of foreign affairs; thence in a line drawn due west to the point where it unites with the line claimed by the United States of America and delineated on the Map A; thence said line to the point at which, according to said map, it coincides with that claimed by Great Britain, and thence the line traced on the map by the two powers to the northwesternmost source of Connecticut River.

* * * * * *

We are of the opinion that the stream situated farthest to the northwest, among those which fall into the northernmost of the three lakes, the last of which bears the name of Connecticut Lake, must be considered as the northwesternmost head of Connecticut River.

* * * * * * *

We are of the opinion that it will be suitable (*il conviendra*) to proceed to fresh operations to measure the observed latitude in order to mark out the boundary from river Connecticut along the parallel of the forty-fifth degree of north latitude to the river Saint Lawrence, named in the treaties Iroquois or Cataraquy, in such a manner, however, that, in all cases, at the place called Rouse's Point the territory of the United States of America shall extend to the fort erected at that place, and shall include said fort and its kilometrical radius (*rayon kilometrique*).

* * * * * * *

However disposed the Government of the United States might have been to acquiesce in the decision of the arbiter, it had not the power to change the boundaries of a State without the consent of the State. Against that alteration the State of Maine entered a solemn protest by the resolutions of 19th January, 1832. And the Senate of the United States did accordingly refuse to give its assent to the award.

The arbitration of the King of the Netherlands having failed, fruitless negotiations ensued for a period of eleven years. Unsuccessful attempts were made to conclude an agreement preparatory to another arbitration. The subject became a matter of great irritation, collisions occurred in the contested territory, and for a time it seemed certain that the controversy would result in war between the two powers. In 1842, however, Great Britain gave unequivocal proof of her desire for the preservation of peace, and an amicable arrangement of the matter at issue, by the special mission of Lord Ashburton to the United States. The subject of this mission was the settlement, not only of the northeastern boundary, but the northern boundary west of the Rocky Mountains. Regarding this object of his mission, Lord Ashburton's instructions gave as the ultimatum of the English Government the boundary as above claimed (p. 16), and, naturally, his mission had no result, as far as this portion of the boundary was concerned.

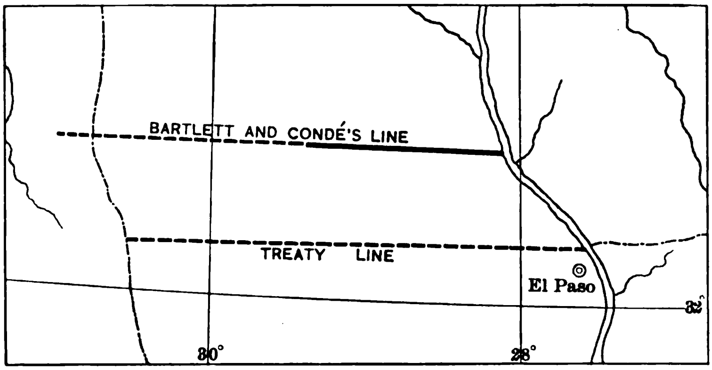
An agreement was reached, however, in regard to the northeastern boundary, which, the consent of the State of Maine having been obtained, was embodied in the treaty concluded August 9, 1842.

TREATY WITH GREAT BRITAIN, 1842.

The following is the text of the portion of this treaty relating to the boundary:

ARTICLE I. It is hereby agreed and declared that the line of boundary shall be as *follows: Beginning* at the monument at the source of the river St. Croix, as desig-

NORTHERN BOUNDARY OF MAINE, SHOWING UNITED STATES AND BRITISH CLAIMS.



PORTION OF DISTURNELL'S MAP OF SOUTHWESTERN BOUNDARY, 1847 (SEE PAGES 25-26).

nated and agreed to by the commissioners under the fifth article of the treaty of 1794, between the Governments of the United States and Great Britain; thence north, following the exploring line run and marked by the surveyors of the two Governments in the years 1817 and 1818, under the fifth article of the treaty of Ghent, to its intersection with the river St. John, and to the middle of the channel thereof; thence up the middle of the main channel of the said river St. John, to the mouth of the river Saint Francis; thence up the middle of the channel of the said river St. Francis, and of the lakes through which it flows, to the outlet of the Lake Pohenagamook; thence southwesterly, in a straight line, to a point on the northwest branch of the river St. John, which point shall be ten miles distant from the main branch of the St. John, in a straight line, and in the nearest direction, but if the said point shall be found to be less than seven miles from the nearest point of the summit or crest of the highlands that divide those rivers which empty themselves into the river St. Lawrence from those which fall into the river St. John, there the said point shall be made to recede down the said northwest branch of the river St. John, to a point seven miles in a straight line from the said summit or crest; thence in a straight line, in a course about south, eight degrees west, to the point where the parallel of latitude 46° 25′ north intersects the southwest branch of the St. John's; thence southerly, by the said branch, to the source thereof in the highlands at the Metjarmette portage; thence down along the said highlands which divide the waters which empty themselves into the river Saint Lawrence from those which fall into the Atlantic Ocean, to the head of Hall's stream; thence down the middle of said stream till the line thus run intersects the old line of boundary surveyed and marked by Valentine and Collins, previously to the year 1774, as the 45th degree of north latitude, and which has been known and understood to be the line of actual division between the States of New York and Vermont on one side, and the British province of Canada on the other; and from said point of intersection, west, along the said dividing line, as heretofore known and understood, to the Iroquois or St. Lawrence River.

ARTICLE II. It is moreover agreed that, from the place where the joint commissioners terminated their labors under the sixth article of the treaty of Ghent, to-wit, at a point in the Neebish channel, near Muddy Lake, the line shall run into and along the ship channel, between St. Joseph and Saint Tammany islands, to the division of the channel at or near the head of St. Joseph's Island; thence turning eastwardly and northwardly around the lower end of St. George's or Sugar Island, and following the middle of the channel which divides St. George's from St. Joseph's Island; thence up the east Neebish channel, nearest to St. George's Island, through the middle of Lake George; thence west of Jonas' Island, into St. Mary's River, to a point in the middle of that river, about one mile above St. George's or Sugar Island, so as to appropriate and assign the said island to the United States; thence, adopting the line traced on the maps by the commissioners, through the river St. Mary and Lake Superior, to a point north of Ile Royale, in said lake, one hundred yards to the north and east of Ile Chapeau, which last mentioned island lies near the northeastern point of Ile Royale, where the line marked by the commissioners terminates; and from the last-mentioned point, southwesterly, through the middle of the sound between Ile Royale and the northwestern mainland, to the mouth of Pigeon River, and up the said river, to and through the north and south Fowl Lakes, to the lakes of the height of land between Lake Superior and the Lake of the Woods; thence along the water communication to Lake Saisaginaga, and through that lake; thence to and through Cypress Lake, Lac du Bois Blanc, Lac la Croix, Little Vermillion Lake, and Lake Namecan, and through the several smaller lakes, straits, or streams, connecting the lakes here mentioned, to that point in Lac la Pluie, or Rainy Lake, at the Chaudière Falls, from which the commissioners traced the line to the most northwestern point of the Lake of the Woods; thence, along the said line, to the said most northwestern point, being in latitude 49° 23′ 55″ north, and in longitude 95° 14′ 38″ west from the observatory at Greenwich; thence, according to existing treaties, due south to its intersection with the forty-ninth parallel of north latitude, and along that parallel to the Rocky Mountains. It being understood that all the water communications and all the usual portages along the line from Lake Superior to the Lake of the Woods, and also Grand Portage, from the shore of Lake Superior to the Pigeon River, as now actually used, shall be free and open to the use of the citizens and subjects of both countries.

* * * * * * *

ARTICLE VII. It is further agreed that the channels in the river St. Lawrence, on both sides of the Long Sault islands, and of Barnhart Island; the channels in the river Detroit, on both sides of the island Bois Blanc, and between that island and both the American and Canadian shores, and all the several channels and passages between the various islands lying near the junction of the river St. Clair with the lake of that name, shall be equally free and open to the ships, vessels, and boats of both parties.

Between 1843 and 1846 there was considerable negotiation regarding the boundary west of the Rocky Mountains, resulting finally in the Webster-Ashburton treaty, which defined the boundary as far west as the straits of Juan de Fuca. The following is that portion of the treaty which defines the boundary.

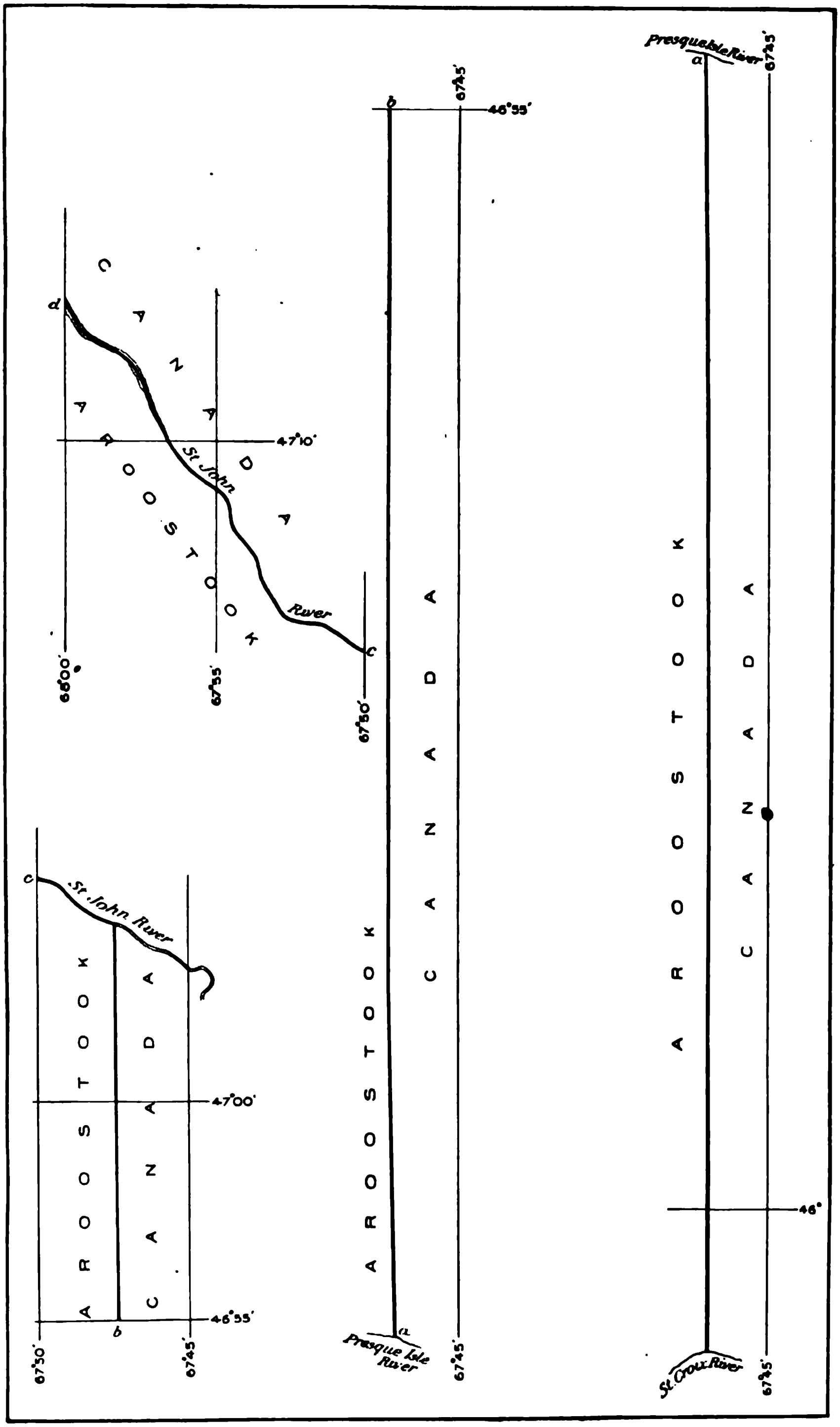
WEBSTER-ASHBURTON TREATY WITH GREAT BRITAIN, 1846.

ARTICLE I. From the point on the forty-ninth parallel of north latitude, where the boundary laid down in existing treaties and conventions between the United States and Great Britain terminates, the line of boundary between the territories of the United States and those of Her Britannic Majesty shall be continued westward along the said forty-ninth parallel of north latitude to the middle of the channel which separates the continent from Vancouver's Island, and thence southerly through the middle of the said channel, and of Fuca's Straits to the Pacific Ocean: *Provided, however*, That the navigation of the whole of the said channel and straits south of the forty-ninth parallel of north latitude remain free and open to both parties.

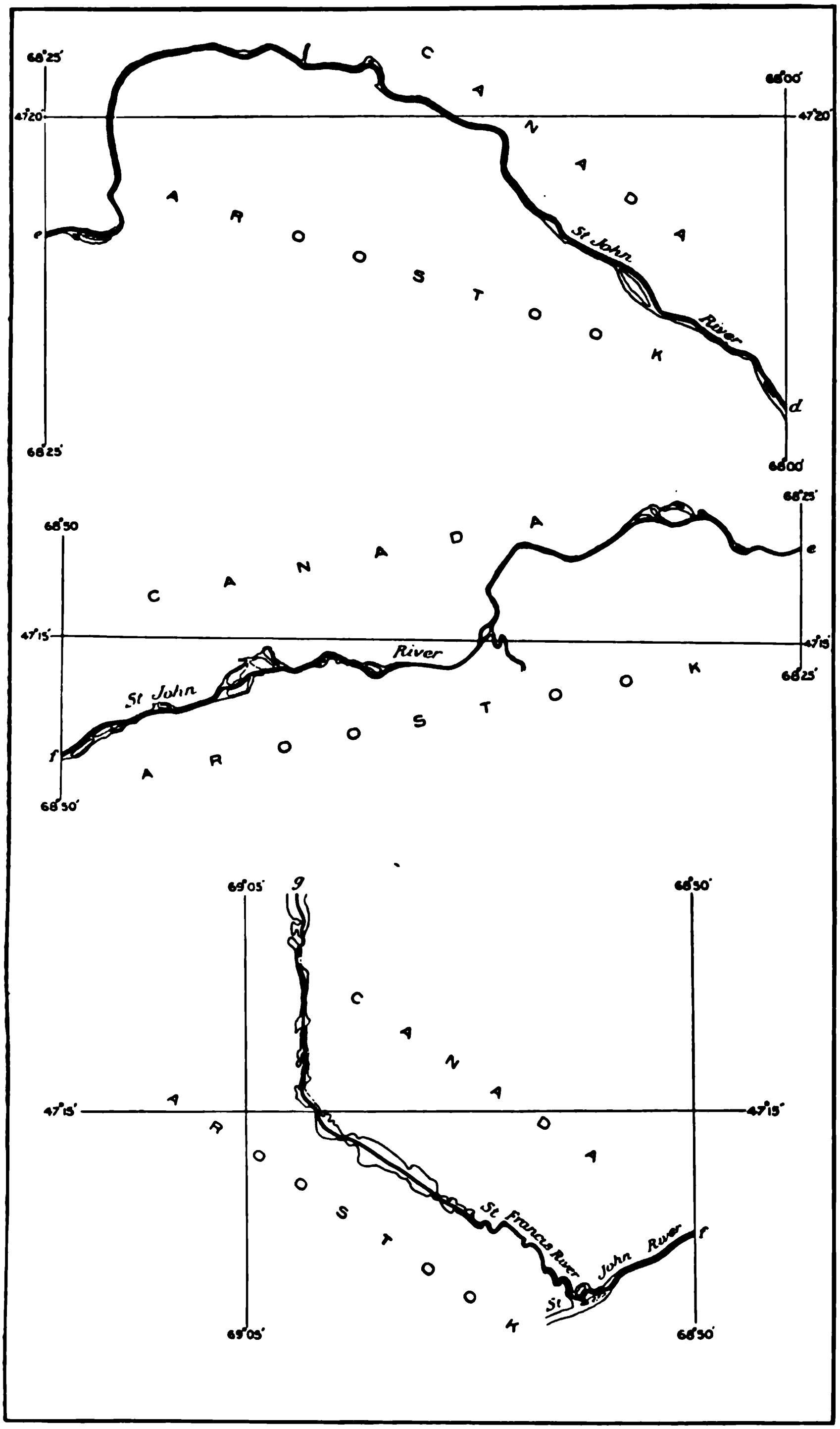
ARTICLE II. From the point at which the forty-ninth parallel of north latitude shall be found to intersect the great northern branch of the Columbia River, the navigation of the said branch shall be free and open to the Hudson's Bay Company, and to all British subjects trading with the same, to the point where the said branch meets the main stream of the Columbia, and thence down the said main stream to the ocean, with free access into and through the said river or rivers, it being understood that all the usual portages along the line thus described shall, in like manner, be free and open. In navigating the said river, or rivers, British subjects, with their goods and produce, shall be treated on the same footing as citizens of the United States; it being, however, always understood that nothing in this article shall be construed as preventing, or intending to prevent, the Government of the United States from making any regulations respecting the navigation of the said river or rivers not inconsistent with the present treaty.

The above treaty extended the line westward from the Rocky Mountains to the Pacific along the forty-ninth parallel of latitude. This settled the northern boundary with the exception of the islands and passages in the straits of Georgia and of Juan de Fuca, the English claiming that the boundary should properly run through the Rosario strait, the most eastern passage, while the United States claimed that it should naturally follow the Strait of Haro.

This matter was finally settled by a reference to the Emperor of Germany as an arbitrator, who decided it in favor of the United States on



BOUNDARY BETWEEN MAINE AND CANADA.



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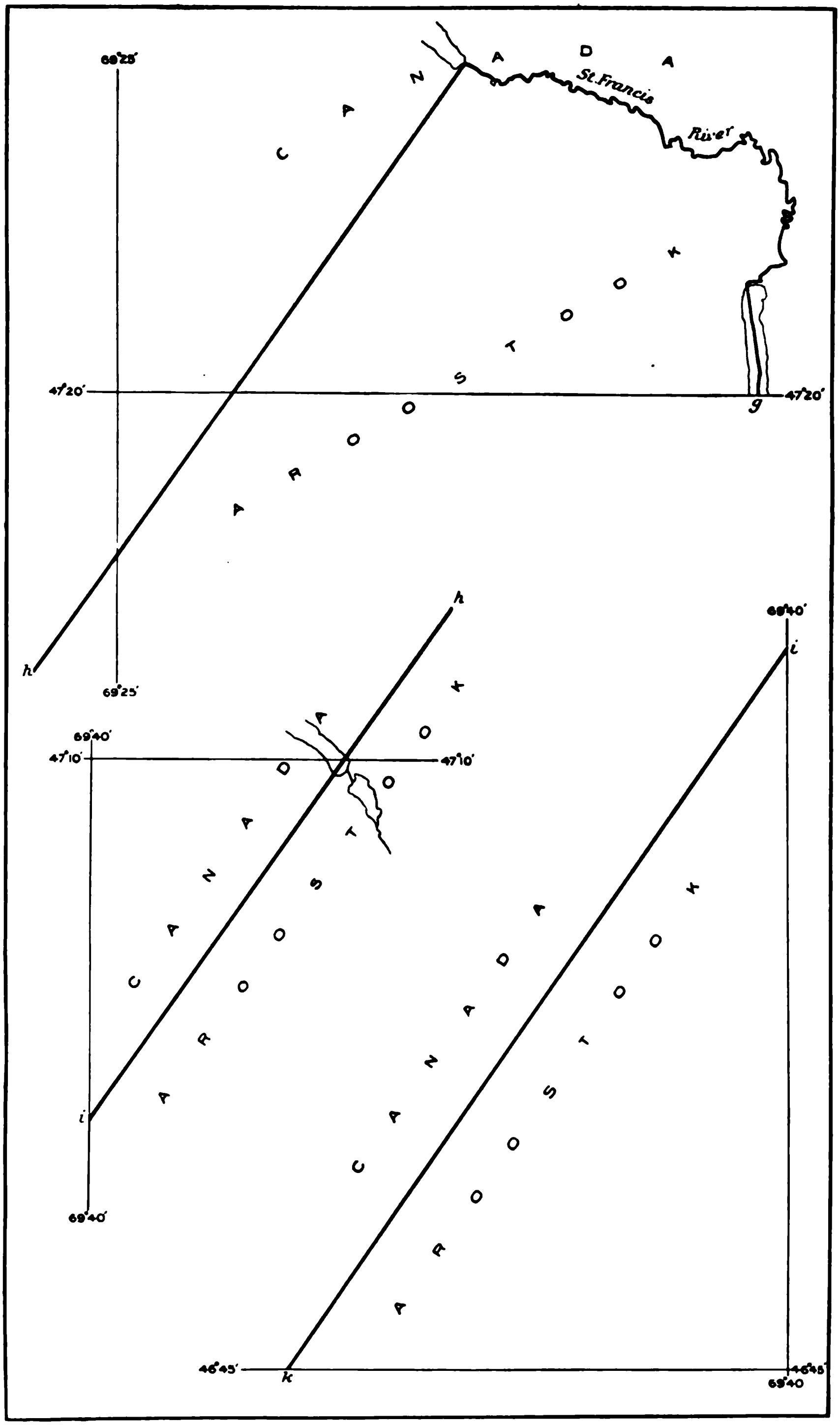

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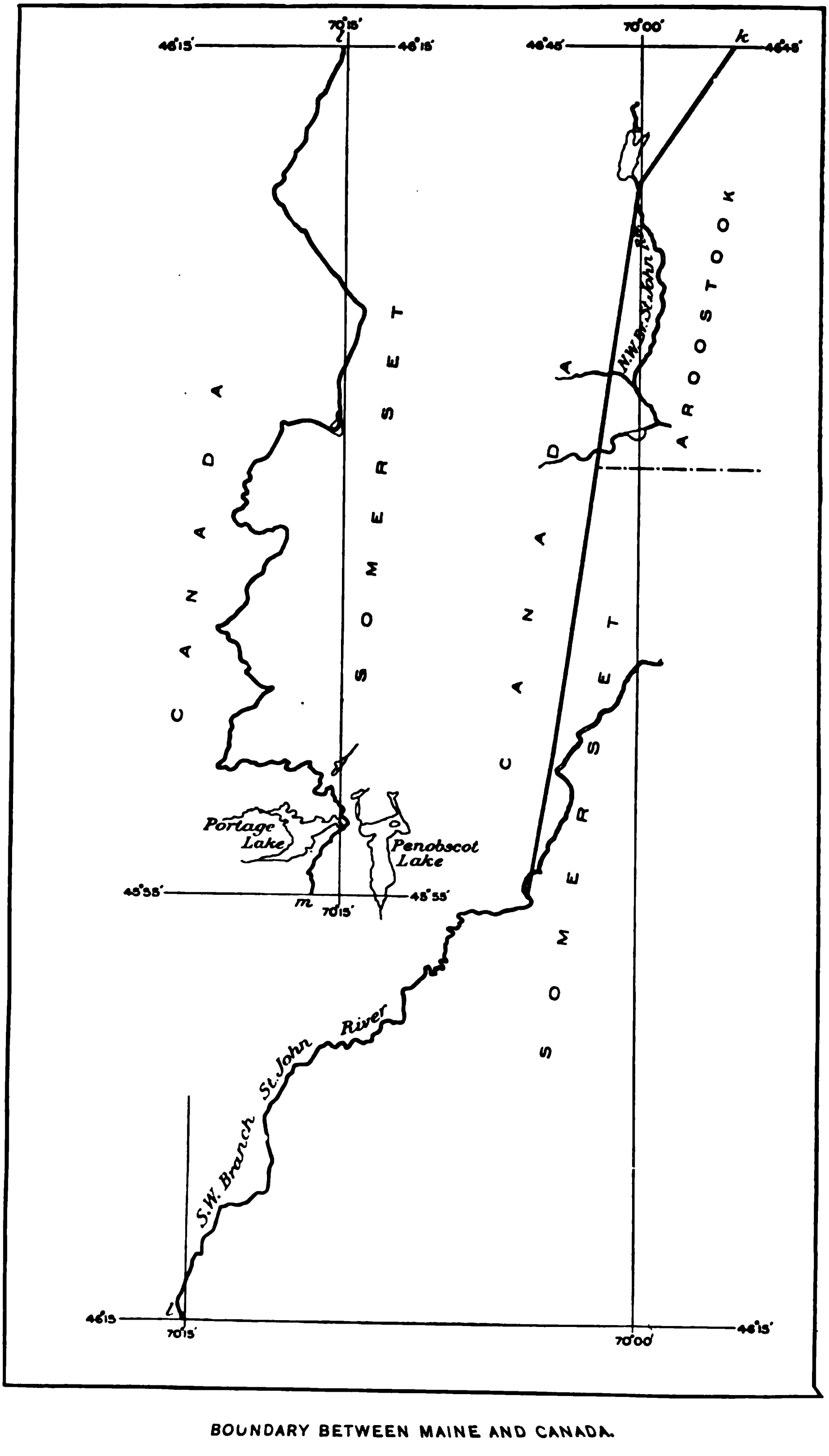

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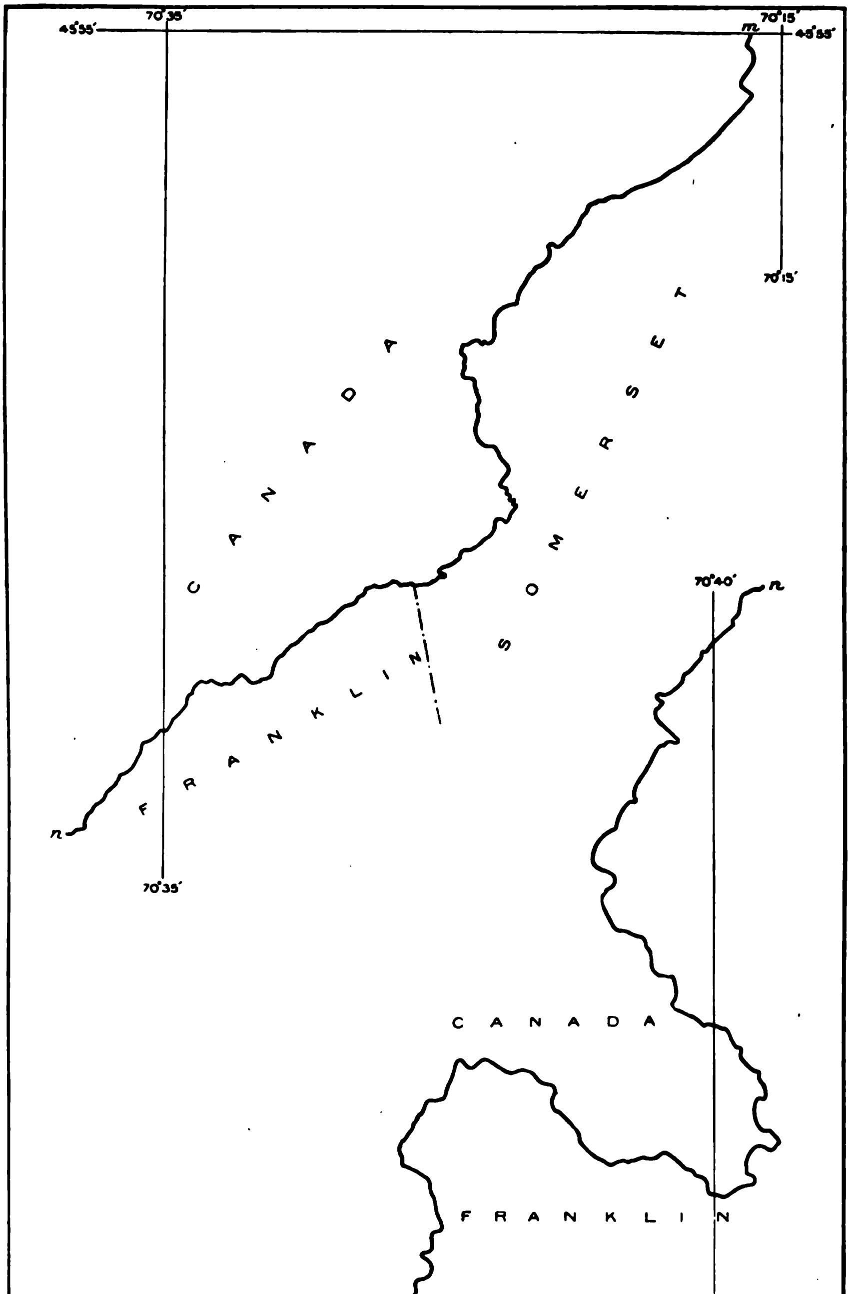
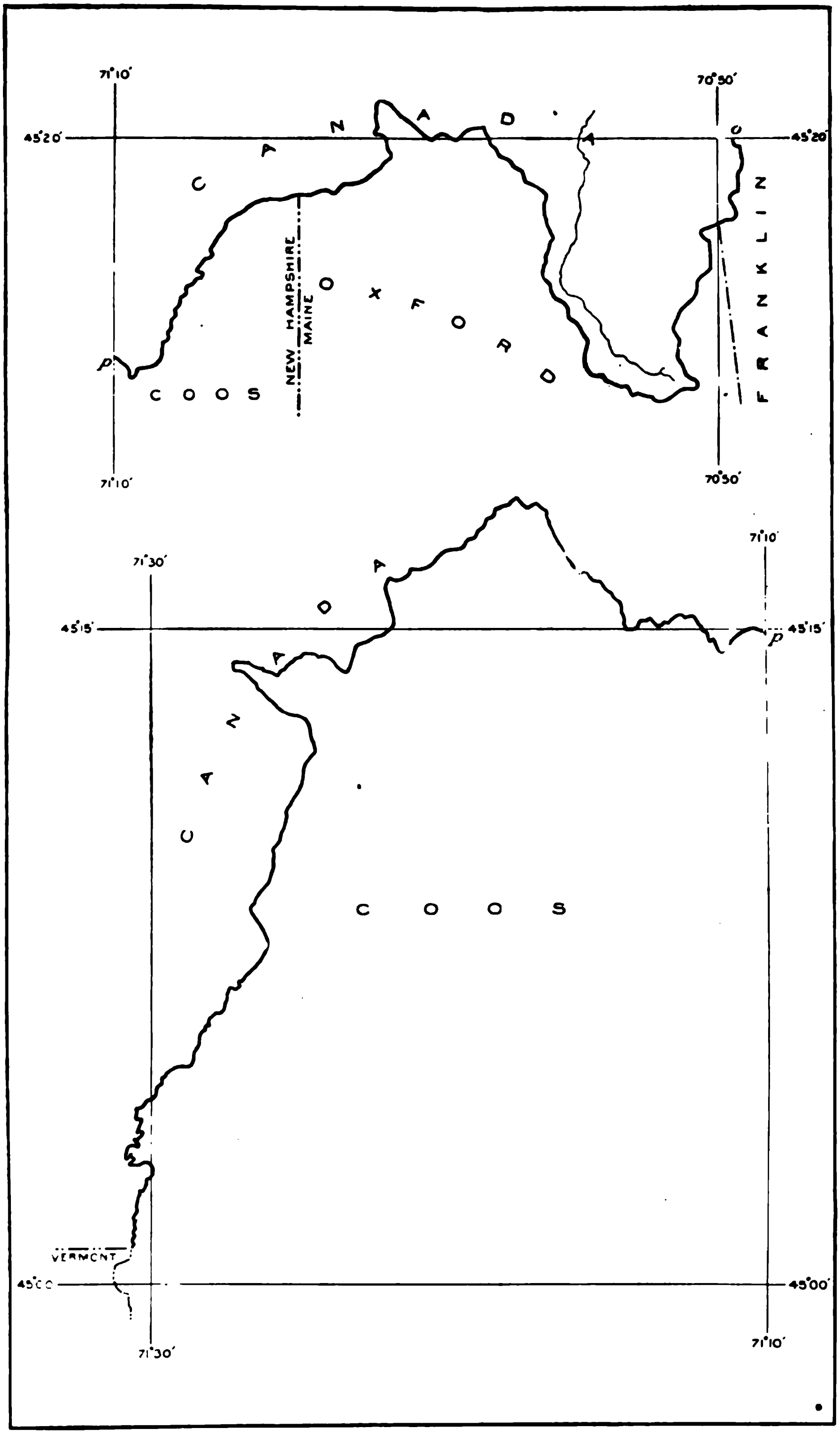


BOUNDARY BETWEEN MAINE AND CANADA.



BOUNDARY BETWEEN MAINE, NEW HAMPSHIRE AND CANADA

the 21st of October, 1872, thus finally disposing of our boundary with Great Britain.

ADDITIONS TO THE TERRITORY OF THE UNITED STATES.

LOUISIANA PURCHASE.

The entire basin of the Mississippi, with much of the coast region of the Gulf of Mexico, which was subsequently known as the territory of Louisiana, was originally claimed by France by virtue of discovery and occupation.

In 1712 France made a grant to Antoine de Crozat, of the exclusive right to the trade of this region. As this grant makes the first, and indeed, the only, statement of the limits of this vast region, as they were understood by France, a portion of it is here introduced.

> We have by these presents signed with our hand, authorized, and do authorize the said Sieur Crozat to carry on exclusively the trade in all the territories by us possessed, and bounded by New Mexico and by those of the English in Carolina, all the establishments, ports, harbors, rivers, and especially the port and harbor of Dauphin Island, formerly called Massacre Island, the river St. Louis, formerly called the Mississippi, from the seashore to the Illinois, together with the river St. Philip, formerly called the Missouries River, and the St. Jerome, formerly called the Wabash (the Ohio), with all the countries, territories, lakes in the land, and the rivers emptying directly or indirectly into that part of the river St. Louis. All the said territories, countries, rivers, streams, and islands we will to be and remain comprised under the name of the government of Louisiana, which shall be dependent on the General Government of New France and remain subordinate to it, and we will, moreover, that all the territories which we possess on this side of the Illinois be united, as far as need be, to the General Government of New France and form a part thereof, reserving to ourself, nevertheless, to increase, if we judge proper, the extent of the government of the said country of Louisiana.

From this it appears that Louisiana was regarded by France as comprising the drainage basin of the Mississippi at least as far north as the mouth of the Illinois, with those of all its branches which enter it below this point, including the Missouri, but excluding that portion in the Southwest claimed by Spain. It is, moreover, certain that the area now comprised in Washington, Oregon, and Idaho was not included.

Crozat surrendered this grant in 1717.

On November 3, 1762, France ceded this region to Spain, defining it only as the province of Louisiana. A few months later, on February 10, 1763, by the treaty of peace between Great Britain, France, and Spain, the western boundary of the former's possessions in the New World was placed in the center of the Mississippi River, thus reducing the area of Louisiana by the portion east of the Mississippi River. Thus by these two treaties France disposed of her possessions in North America, dividing them between Great Britain and Spain. The limit set between their possessions was given as the Mississippi, the river Iberville, and lakes Maurepas and Pontchartrain.

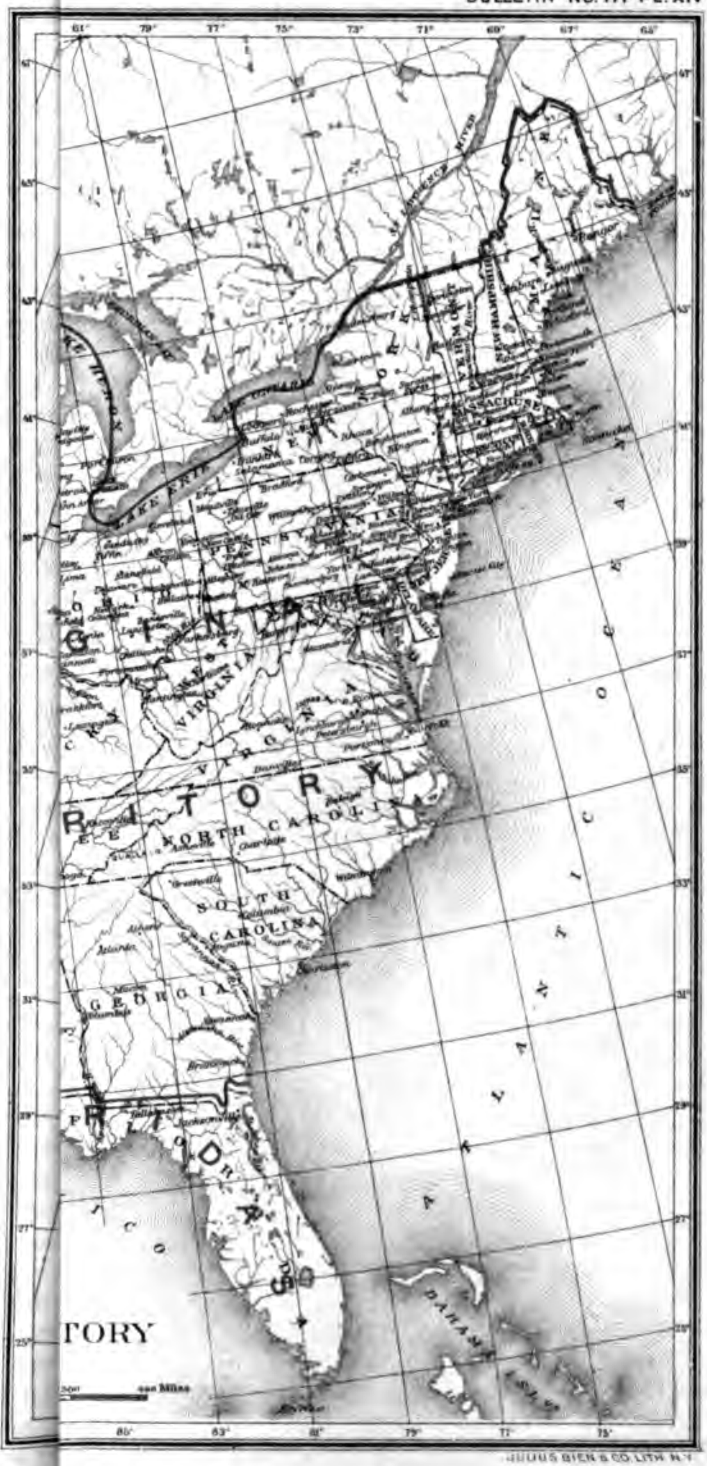
Great Britain then proceeded to subdivide her share of this territory. The area south of a meridian through the mouth of Yazoo River and west of Apalachicola River she called West Florida; the region east thereof and south of the present north boundary of Florida received the name of East Florida. For the following twenty years, i. e., up to 1783, these boundaries and names remained undisturbed. In the latter year, by the treaty of peace with the United States at the close of the Revolution, Great Britain reduced the area of West Florida by the cession of that portion north of the thirty-first parallel to the United States. In the same year she gave East Florida and what remained of West Florida to Spain, and in Spain's possession they remained until ceded to the United States in 1819.

Meantime, in 1800, by the secret treaty of San Ildefonso, Spain promised to return Louisiana to France. In the language of the treaty, she pledged herself to return to France the "Province of Louisiana, with the same extent it now has in the hands of Spain, and that it had when Spain possessed it, and such as it should be after the treaties subsequently entered into between Spain and other States."

Immediately after this transfer became known, on November 30, 1802, measures were set on foot by President Jefferson for securing in some way free access to the sea by way of the Mississippi River. Circumstances favored this negotiation. Bonaparte was at that time in almost daily expectation of a declaration of war by Great Britain, in which case the first act of the latter would be to seize the mouth of the Mississippi, and with it the province of Louisiana. Under these circumstances Bonaparte offered to sell the province to the United States, and the offer was promptly accepted. The consideration was 60,000,000 francs and the assumption by the United States of the "French spoliation claims," which were estimated to amount to $3,750,000.

The treaty of cession, which bears date April 30, 1803, describes the territory only as being the same as ceded by Spain to France by the treaty of San Ildefonso.

From this it appears that the territory sold to the United States comprised that part of the drainage basin of the Mississippi which lies west of the course of the river, with the exception of such parts as were then held by Spain. The want of precise definition of limits in the treaty was not objected to by the American commissioners, as they probably foresaw that this very indefiniteness might prove of service to the United States in future negotiations with other powers. In fact, the claim of the United States to the area now comprised in Oregon, Washington, and Idaho in the negotiations with Great Britain regarding the northwestern boundary, was ostensibly based, not only upon prior occupation and upon purchase from Spain, but also upon the alleged fact that this area formed part of the Louisiana purchase. That this claim was baseless is shown not only by what has been already detailed regarding the limits of the purchase, but also by the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NEW YORK
Buffalo
Ithaca
PENNSYLVANIA
MASSACHUSETTS
OHIO
WEST VIRGINIA
VIRGINIA
TORY
NORTH CAROLINA
Raleigh
Charlotte
Wilmington
SOUTH CAROLINA
Columbia
Atlanta
Macon
GEORGIA
Savannah
Jacksonville
Tallahassee
FLORIDA
ATLANTIC OCEAN
BAHAMA ISLS.
TORY
200 Miles
85°
83°
81°
79°
77°
75°

direct testimony of the French plenipotentiary, M. Barbé Marbois. Some twenty years after the purchase he published a work upon Louisiana, in which he detailed at some length the negotiations which preceded the purchase, and, referring to this question said: "The shores of the western ocean were certainly not comprised in the cession, but already the United States are established there."

There is also contained in this work a map of the country between the Mississippi and the Pacific, on which the extent of Louisiana to the westward is indicated by a line drawn on the one hundred and tenth meridian, which is not far from the western limit of the drainage basin of the Mississippi in Wyoming and Montana. That part of the country now comprised in Oregon, Washington, and Idaho, which, it has been claimed, formed part of the purchase, bears the following legend: "Territories and countries occupied by the United States, following the treaty of cession of Louisiana."

From this it appears that the northwestern limits of the Louisiana purchase can no longer be a matter of discussion; but although the United States certainly did not purchase Oregon, as a part of Louisiana, it is no less certain that that great area west of the Rocky Mountains fell into their hands as a direct consequence of such purchase.

FLORIDA PURCHASE.

The second addition to the territory of the United States consisted of the Floridas, purchased from Spain on February 22, 1819. From the date of the Louisiana purchase, in 1803, the territory bounded by the Mississippi River on the west, the Perdido on the east, the parallel of 31° on the north, and the Gulf on the south had been in dispute between the two countries. During a part of this time it had been practically in the possession of the United States.

The clause quoted above from the treaty of San Ildefonso was interpreted by Jefferson and others in this country to mean the inclusion of West Florida. Their reasoning was this: In 1800 Spain owned West Florida; West Florida was once a part of Louisiana; in 1800 Spain re-ceded Louisiana to France; she therefore re-ceded West Florida with it.

Spain, however, held that this was merely a treaty of recession, by which she gave back to France what France had given to her in 1762. Since in 1762 she did not own West Florida, she could not, therefore, have re-ceded it to France.

As to this matter, Marbois, the French plenipotentiary, was very positive in stating that West Florida formed no part of the Louisiana purchase, and that the southeastern boundary of the latter was the river Iberville and lakes Maurepas and Pontchartrain.

Immediately after the Louisiana purchase the claim was made by the United States that it included most of West Florida, and also a part of the Texas coast, but this was not entertained by Spain. In 1810 a revolution was effected in that part of West Florida lying west of Pearl River, and application was made for annexation to the United States. The governor of Louisiana, under instructions from Washington, at once took possession, but immediately a counter revolution was organized against him, which was put down by force of arms, and in 1812 this part of West Florida was annexed to the State of Louisiana. Meantime, the insurrection spread eastward in West Florida, and, although put down by Spanish authorities, the movement received the sympathy of the United States, which passed a secret act authorizing the President, under certain specified contingencies, to use force in taking possession of the Floridas. In 1812 that portion of West Florida lying between Perdido and Pearl rivers was annexed to the Territory of Mississippi.

This purchase settled these conflicting claims.

The following is the clause in the treaty with Spain ceding the Floridas which defines the cession:

> ART. 2. His Catholic Majesty cedes to the United States, in full property and sovereignty, all the territories which belong to him, situated to the eastward of the Mississippi, known by the name of East and West Florida, the adjacent islands dependent upon said province, etc.

A further article in this treaty defines the boundary between the United States and the Spanish possessions in the Southwest, as follows:

> The boundary line between the two countries, west of the Mississippi, shall begin on the Gulf of Mexico, at the mouth of the river Sabine, in the sea, continuing north, along the western bank of that river, to the thirty-second degree of latitude, thence by a line due north to the degree of latitude where it strikes the Rio Roxo of Nachitoches, or Red River; then following the course of the Rio Roxo to the degree of longitude 100 west from London, or about 23° west of Washington; then crossing the said Rio Roxo and running thence, by a line due north, to the River Arkansas; thence, following the course of the southern bank of the Arkansas, to its source in latitude 42 north; and thence by that parallel of latitude to the South Sea, the whole being as laid down in Melish's map of the United States, published at Philadelphia, improved to the 1st of January, 1818. But if the source of the Arkansas River shall be found to fall north or south of latitude 42, then the line shall run from the said source due south or north, as the case may be, till it meets the said parallel of latitude 42, and thence along the said parallel to the South Sea, all the islands in the Sabine and the said Red and Arkansas rivers, throughout the course thus described, to belong to the United States; but the use of the waters, and the navigation of the Sabine to the sea, and of the said rivers Roxo and Arkansas throughout the extent of the said boundary on their respective banks shall be common to the respective inhabitants of both nations.

TEXAS ACCESSION.

The next acquisition of territory was that of the Republic of Texas, which was admitted as a State on December 29, 1845. The area which Texas brought into the Union was limited as follows, as defined by the Republic of Texas, December 19, 1836:

> Beginning at the mouth of the Sabine River and running west along the Gulf of Mexico three leagues from land to the mouth of the Rio Grande, thence up the principal stream of that river to its source, thence due north to the forty-second degree [illegible] north latitude, thence along the boundary line as defined in the treaty between in and the United States, to the beginning.

FIRST MEXICAN CESSION.

In 1848 a further addition was made to our territory by the treaty of Guadalupe-Hidalgo. This added to the country the area of California, Nevada, Utah, and parts of Colorado, Arizona, and New Mexico, while the Gadsden purchase, which was effected in 1853, added the remainder of Arizona and another part of New Mexico.

The treaty of Guadalupe-Hidalgo was concluded February 2, 1848, and proclaimed July 4, 1848. The clauses in it defining our acquisition of territory are as follows:

> ARTICLE V. The boundary line between the two Republics shall commence in the Gulf of Mexico, three leagues from land, opposite the mouth of the Rio Grande, otherwise called the Rio Bravo del Norte, or opposite the mouth of its deepest branch, if it should have more than one branch emptying into the sea; from thence up the middle of that river, following the deepest channel where it has more than one, to the point where it strikes the southern boundary of New Mexico; thence westwardly along the whole southern boundary of New Mexico (which runs north of the town called Paso) to its western termination; thence northward along the western line of New Mexico until it intersects the first branch of the river Gila (or if it should not intersect any branch of that river, then to the point on the said line nearest to such branch, and thence in a direct line to the same); thence down the middle of the said branch and of the said river until it empties into the Rio Colorado; thence across the Rio Colorado, following the division line between Upper and Lower California, to the Pacific Ocean.
>
> The southern and western limits of New Mexico, mentioned in this article, are those laid down in the map entitled, "Map of the United Mexican States as organized and defined by various acts of the Congress of said Republic, and constructed according to the best authorities. Revised edition. Published at New York, in 1847, by J. Disturnell;" of which map a copy is added to this treaty, bearing the signatures and seals of the undersigned plenipotentiaries. And in order to preclude all difficulty in tracing upon the ground the limit separating Upper from Lower California, it is agreed that the said limit shall consist of a straight line drawn from the middle of the Rio Gila, where it unites with the Colorado, to a point on the coast of the Pacific Ocean, distant one marine league due south of the southernmost point of the port of San Diego, according to the plan of said port made in the year 1782, by Don Juan Pautoja, second sailing master of the Spanish fleet, and published at Madrid in the year 1802, in the atlas to the voyage of the schooners Sutil and Mexicana; of which plan a copy is hereunto added, signed, and sealed by the respective plenipotentiaries.

Much difficulty followed in the interpretation of this treaty. A joint commission of the two Governments was formed, consisting of a commissioner and a chief surveyor from each. They were instructed that any decision upon the interpretation of the treaty must be agreed to unanimously. The most important question coming before the commission for decision concerned the location and extent of the south boundary of New Mexico. Here, unfortunately, the Disturnell map left room for broad difference in opinion. The town called Paso is incorrectly located upon the map to the extent of nearly half a degree of latitude, or, in other words, the parallels of latitude are misplaced to this extent, so that if the position of the south boundary of New Mexico be accepted with reference to the nearest parallel of latitude, it is half a degree farther north than it would be if its position were measured from the town of Paso.

In the absence of the chief surveyor the other three members of the commission, including Mr. J. R. Bartlett, United States commissioner, agreed to accept the position of the south boundary of New Mexico as shown by the projection lines of the map; to run a line in this latitude 3 degrees west from the Rio Grande, and from the end of this line to run north until a branch of Gila River was intersected. In accordance with this decision a durable monument was erected on the bank of the Rio Grande, in latitude 32° 22′, and the line was run a degree and a half to the westward. At this time the chief surveyor arrived, learned what had been done, and made a vigorous protest against this interpretation of the map. This protest, backed by Major Emory, the chief astronomer, caused a sudden stoppage of the work of running the line and the repudiation of the agreement by the United States Government. Negotiations followed, but no agreement was reached until in 1853 the whole matter was taken out of court by the Gadsden purchase.

GADSDEN PURCHASE.

Subsequently, on December 30, 1853, a second purchase was made of Mexico, consisting of the strip of land lying south of the Gila River, in New Mexico and Arizona. The boundaries as established by this, known as the Gadsden purchase, were as follows:

> ARTICLE I. The Mexican Republic agrees to designate the following as her true limits with the United States for the future: Retaining the same dividing line between the two Californias as already defined and established, according to the fifth article of the treaty of Guadalupe-Hidalgo, the limits between the two Republics shall be as follows: Beginning in the Gulf of Mexico, three leagues from land, opposite the mouth of the Rio Grande, as provided in the fifth article of the treaty of Guadalupe-Hidalgo; thence, as defined in the said article, up the middle of that river to the point where the parallel of 31° 47′ north latitude crosses the same; thence due west one hundred miles; thence south to the parallel of 31° 20′ north latitude; thence along the said parallel of 31° 20′ to the one hundred and eleventh meridian of longitude west of Greenwich; thence in a straight line to a point on the Colorado River twenty English miles below the junction of the Gila and Colorado rivers; thence up the middle of the said river Colorado until it intersects the present line between the United States and Mexico.

In the year following a commission was appointed for surveying and marking this line, under the United States commissioner, Maj. W. H. Emory. The line was run and marked in the year 1855, and the report was transmitted in the following year.

As settlement increased in the territory which this line traverses the fact was developed that the line was insufficiently marked. Some of the monuments had disappeared and in many places there were great extents of country in which no monuments had ever been placed, so that the necessity became apparent for rerunning and marking of the line. For this purpose a commission was created in 1891, the United States members of which were Col. J. W. Barlow and Capt. D. D. Gaillard, Corps of Engineers, U. S. A., and Mr. A. T. Mosman of the United States Coast and Geodetic Survey. Under this commission the line was recovered from the original monuments as far as possible, and between these monuments was rerun and fully and durably marked. The report, with maps, profiles, and illustrations of the monuments, was published in 1899.

ALASKA PURCHASE.

Alaska was purchased from Russia, the treaty of purchase having been signed on March 30, 1867, and proclaimed June 20, 1867. The boundaries of the territory are described in the accompanying quotation from the treaty:

> Commencing from the southernmost point of the island called Prince of Wales Island, which point lies in the parallel of 54° 40″ north latitude, and between the one hundred and thirty-first and one hundred and thirty-third degree of west longitude (meridian of Greenwich), the said line shall ascend to the north along the channel called Portland Channel as far as the point of the continent where it strikes the fifty-sixth degree of north latitude; from this last-mentioned point the line of demarkation shall follow the summit of the mountains situated parallel to the coast as far as the point of intersection of the one hundred and forty-first degree of west longitude (of the same meridian); and, finally, from the said point of intersection the said meridian line of the one hundred and forty-first degree in its prolongation as far as the Frozen Ocean.
>
> IV. With reference to the line of demarkation laid down in the preceding article it is understood—
>
> 1st. That the island called Prince of Wales Island shall belong wholly to Russia (now, by this cession, to the United States).
>
> 2d. That whenever the summit of the mountains which extend in a direction parallel to the coast from the fifty-sixth degree of north latitude to the point of intersection of the one hundred and forty-first degree of west longitude shall prove to be at the distance of more than ten marine leagues from the ocean, the limit between the British possessions and the line of coast which is to belong to Russia, as above mentioned (that is to say, the limit to the possessions ceded by this convention), shall be formed by a line parallel to the winding of the coast, and which shall never exceed the distance of ten marine leagues therefrom.
>
> The western limit within which the territories and dominion conveyed are contained passes through a point in Behring's Straits on the parallel of 65° 30′ north latitude at its intersection by the meridian which passes midway between the islands of Krusenstern or Ignalook and the island of Ratmanoff or Noonerbook, and proceeds due north without limitation into the same Frozen Ocean.
>
> The same western limit, beginning at the same initial point, proceeds thence in a course nearly southwest through Behring's Straits and Behring's Sea, so as to pass midway between the northwest point of the island of Saint Lawrence and the southeast point of Cape Choukotski to the meridian of one hundred and seventy-two west longitude; thence from the intersection of that meridian in a southwesterly direction, so as to pass midway between the island of Attore and the Copper Island of the Kormandorski couplet or group, in the North Pacific Ocean, to the meridian of one hundred and ninety-three degrees west longitude, so as to include in the territory conveyed the whole of the Aleutian Islands west of that meridian.

The consideration paid for Alaska was $7,200,000 in gold.

There is no possibility of a misinterpretation of the language of the above treaty concerning the portion of the boundary running along the one hundred and forty-first meridian from the shores of the Arctic Ocean to the neighborhood of the coast near Mount St. Elias, and in recent years points upon this boundary, notably at the crossing of the Yukon, have been established by the United States and Canadian surveyors by astronomic means and marked.

Concerning the remaining portion of the boundary, however, from the neighborhood of Mount St. Elias southeastward to the mouth of Portland Canal, question has been raised in recent years by Canadian authorities.

It has long been known that the coast of this part of Alaska is extremely broken, containing many fiords extending far inland, and that no continuous range of mountains parallels the coast. It was for many years tacitly admitted by both sides that the second alternative of the treaty, that the boundary should follow a line 10 marine leagues distant from the coast and following its windings, should be the one finally adopted when the question of marking the boundary arose. This position was taken by the United States and consistently followed from the time of the acquisition of the territory to the present. All maps, United States and Canadian, agreed on it. Many acts of sovereignty were performed by the United States within this territory, no question being raised by the Canadian authorities, and the claim of the United States to a strip of territory 10 marine leagues in width from the main coast was universally admitted by the Canadian authorities. The discovery of gold in the basin of the Yukon, in Canada, and the fact that the only feasible means of access to this region lay through United States territory, made it extremely desirable for Canada to possess a port or ports on this coast as the starting points of routes to the Yukon mines, and it was only when this necessity appeared that any question arose concerning the interpretation of the definition of limits in the treaty.

The claim made by the British Government, before a joint commission on the boundary, on behalf of Canada, in August, 1898, was that this portion of the boundary, instead of passing up Portland Canal, should pass up Pearse Canal, connecting with Portland Canal, up which it follows to the summit of the mountains nearest to the coast, and then should follow them, regardless of the fact that they do not form a continuous range, crossing all the inlets of the sea up to Mount St. Elias. This, of course, was refused by the United States commissioners. A proposition made by the British commissioners to refer the matter to arbitration was also refused by the United States commissioners, on the ground that there was nothing to arbitrate, since the territory in question was in the possession of the United States, and had been for many years without dispute, such possession being in full accord with the terms of the treaty. The commission was then dissolved, the only outcome being an agreement that the summits of White and Chilkoot passes and a point upon the Chilkat, above Pyramid Harbor, were temporarily adopted as points upon the boundary.

HAWAIIAN ISLANDS.

The Republic of Hawaii, comprising eight islands in the Pacific, voluntarily joined the United States in 1898.

PORTO RICO, GUAM, AND PHILIPPINE ISLANDS.

The latest accession of territory made by the United States were the islands taken from Spain following the war of 1898. These were relinquished to the United States by the treaty of peace of December 10, 1898. They were as follows:

Cuba, sovereignty over which was relinquished by Spain and assumed by the United States. With Cuba was included the Isle of Pines and the islets scattered around the Cuban coast.

Porto Rico and other Spanish West India islands which were ceded to the United States.

The island of Guam, in the Ladrones.

The Philippine Islands, which comprise all the islands lying within the following line, as defined in the words of the treaty:

> A line running from west to east along or near the twentieth parallel of north latitude, and through the middle of the navigable channel of Bachi, from the one hundred and eighteenth (118th) to the one hundred and twenty-seventh (127th) degree meridian of longitude east of Greenwich; thence along the one hundred and twenty-seventh (127th) degree meridian of longitude east of Greenwich to the parallel of four degrees and forty-five minutes (4° 45′) north latitude; thence along the parallel of four degrees and forty-five minutes (4° 45′) north latitude to its intersection with the meridian of longitude one hundred and nineteen degrees and thirty-five minutes (119° 35′) east of Greenwich; thence along the meridian of longitude one hundred and nineteen degrees and thirty-five minutes (119° 35′) east of Greenwich to the parallel of latitude seven degrees and forty minutes (7° 40′) north; thence along the parallel of latitude seven degrees and forty minutes (7° 40′) north to its intersection with the one hundred and sixteenth (116th) degree meridian of longitude east of Greenwich; thence by a direct line to the intersection of the tenth (10th) degree parallel of north latitude with the one hundred and eighteenth (118th) degree meridian of longitude east of Greenwich; and thence along the one hundred and eighteenth (118th) degree meridian of longitude east of Greenwich to the point of beginning.

For the Philippines the sum of $20,000,000 was paid by the United States to Spain.

CHAPTER II.

THE PUBLIC DOMAIN AND AN OUTLINE OF THE HISTORY OF CHANGES MADE THEREIN.

CESSIONS BY THE STATES.

At the time the Constitution was adopted by the original thirteen States, many of them possessed unoccupied territory, in some cases entirely detached and lying west of the Appalachian Mountains. Thus, Georgia included the territory from its present eastern limits westward to the Mississippi River. North Carolina possessed a narrow strip extending from latitude 35° to 36° 30′, approximately, and running westward to the Mississippi, including besides its own present area that of the present state of Tennessee. In like manner, Virginia possessed what is now Kentucky, while a number of States, as Pennsylvania, New York, Massachusetts, and Connecticut, laid claim to areas in what was afterward known as the Territory Northwest of the River Ohio, a region which is now comprised mainly in the States of Ohio, Indiana, Illinois, Michigan, and Wisconsin. These claims were to a greater or less extent conflicting. In some cases several States claimed authority over the same area, while the boundary lines were in most cases very ill-defined.

The ownership of these western lands by individual States was opposed by those States which did not share in their possession, mainly on the ground that the resources of the General Government, to which all contributed, should not be taxed for the protection and development of this region, while its advantages would inure to the benefit of but a favored few. On this ground several of the States refused to ratify the Constitution until this matter had been settled by the cession of these tracts to the General Government.

Moved by these arguments, as well as by the consideration of the conflicting character of the claims, which must inevitably lead to trouble among the States, Congress passed, on October 30, 1779, the following act:

> Whereas the appropriation of the vacant lands by the several States during the present war will, in the opinion of Congress, be attended with great mischiefs: Therefore,
>
> *Resolved*, That it be earnestly recommended to the State of Virginia to reconsider their late act of assembly for opening their land office; and that it be recommended to the said State, and all other States similarly circumstanced, to forbear settling or issuing warrants for unappropriated lands, or granting the same during the continuance of the present war.

This resolution was transmitted to the different States. The first to respond to it by the transfer of her territory to the General Government was New York, whose example was followed by the other States.

These cessions were made on the dates given below:

New York, March 1, 1781.

Virginia, March 1, 1784.

Massachusetts, April 19, 1785

Connecticut, September 13, 1786.

The Connecticut act of cession reserved an area in the northeastern part of Ohio, known as the Western Reserve. On May 30, 1800, Connecticut gave to the United States jurisdiction over this area, but without giving up its property rights in it.

South Carolina, August 9, 1787.

North Carolina, February 25, 1790.

Georgia, April 24, 1802.

The following paragraph from the deed of cession by New York defines the limits of its cession to the General Government:

> Now, therefore, know ye, that we, the said James Duane, William Floid, and Alexander M'Dougall, by virtue of the power and authority, and in the execution of the trust reposed in us, as aforesaid, have judged it expedient to limit and restrict, and we do, by these presents, for and in behalf of the said State of New York, limit and restrict the boundaries of the said State in the western parts thereof, with respect to the jurisdiction, as well as the right or pre-emption of soil, by the lines and in the form following, that is to say: a line from the northeast corner of the State of Pennsylvania, along the north bounds thereof to its northwest corner, continued due west until it shall be intersected by a meridian line to be drawn from the forty-fifth degree of north latitude, through the most westerly bent or inclination of Lake Ontario; thence by the said meridian line to the forty-fifth degree of north latitude; and thence by the said forty-fifth degree of north latitude; but if, on experiment, the above-described meridian line shall not comprehend twenty miles due west from the most westerly bent or inclination of the river or strait of Niagara, then we do, by these presents, in the name of the people, and for and on behalf of the State of New York, and by virtue of the authority aforesaid, limit and restrict the boundaries of the said State in the western parts thereof, with respect to jurisdiction, as well as the right of pre-emption of soil, by the lines and in the manner following, that is to say: a line from the northeast corner of the State of Pennsylvania, along the north bounds thereof, to its northwest corner, continued due west until it shall be intersected by a meridian line, to be drawn from the forty-fifth degree of north latitude, through a point twenty miles due west from the most westerly bent or inclination of the river or strait Niagara; thence by the said meridian line to the forty-fifth degree of north latitude, and thence by the said forty-fifth degree of north latitude.

The deed of cession by Virginia gives no limits, further than to specify that the lands transferred include only those lying northwest of the river Ohio.

The following paragraph from the deed of cession by Massachusetts gives the limits of the area ceded:

> * * * We do by these presents assign, transfer, quitclaim, cede, and convey to the United States of America, for their benefit, Massachusetts inclusive, all right, title, and estate of and in, as well the soil as the jurisdiction, which the said Com-

monwealth hath to the territory or tract of country within the limits of Massachusetts charter situate and lying west of the following line, that is to say, a meridian line to be drawn from the forty-fifth degree of north latitude through the westerly bent or inclination of Lake Ontario, thence by the said meridian line to the most southerly side line of the territory contained in the Massachusetts charter; but if on experiment the above-described meridian line shall not comprehend twenty miles due west from the most westerly bent or inclination of the river or strait of Niagara, then we do by these presents, by virtue of the power and authority aforesaid, in the name and on behalf of the said Commonwealth of Massachusetts, transfer, quitclaim, cede, and convey to the United States of America, for their benefit, Massachusetts inclusive, all right, title, and estate of and in as well the soil as the jurisdiction, which the said Commonwealth hath to the territory or tract of country within the limits of the Massachusetts charter, situate and lying west of the following line, that is to say, a meridian line to be drawn from the forty-fifth degree of north latitude through a point twenty miles due west from the most westerly bent or inclination of the river or strait of Niagara; thence by the said meridian line to the most southerly side line of the territory contained in the Massachusetts charter aforesaid.

The following clause from the act of the legislature of Connecticut, authorizing the cession, defines its limits:

Be it enacted * * * That the delegates of this State, or any two of them, who shall be attending the Congress of the United States, be, and they are hereby, directed, authorized, and fully empowered, in the name and behalf of this State, to make, execute, and deliver, under their hands and seals, an ample deed of release and cession of all the right, title, interest, jurisdiction, and claim of the State of Connecticut to certain western lands, beginning at the completion of the forty-first degree of north latitude, one hundred and twenty miles west of the western boundary line of the Commonwealth of Pennsylvania, as now claimed by said Commonwealth, and from thence by a line drawn north, parallel to and one hundred and twenty miles west of the said west line of Pennsylvania, and to continue north until it comes to forty-two degrees and two minutes north latitude. Whereby all the right, title, interest, jurisdiction, and claim of the State of Connecticut to the lands lying west of said line to be drawn as aforementioned, one hundred and twenty miles west of the western boundary line of the Commonwealth of Pennsylvania, as now claimed by said Commonwealth, shall be included, released, and ceded to the United States in Congress assembled, for the common use and benefit of the said States, Connecticut inclusive.

The cession of South Carolina was described as follows:

* * * All the territory or tract of country included within the river Mississippi and a line beginning at that part of the said river which is intersected by the southern boundary line of the State of North Carolina, and continuing along the said boundary line until it intersects the ridge or chain of mountains which divides the eastern from the western waters, then to be continued along the top of said ridge of mountains until it intersects a line to be drawn due west from the head of the southern branch of Tugaloo River to the said mountains; from thence to run a due west course to the river Mississippi.

The State of North Carolina ceded—

The lands situated within the chartered limits of the State, west of a line beginning on the extreme height of Stone Mountain, at the place where the Virginia line intersects it; running thence along the extreme height of the said mountain to the place where the Watauga River breaks through it; thence a direct course to the top of the Yellow Mountain where Bright's road crosses the same; thence along the ridge of the said mountain, between the waters of Doe River and the waters of Rock Creek, to the place where the road crosses the Iron Mountain; from thence along the extreme height of the said mountain to where Nolechucky River runs through the same; thence to the top of the Bald Mountain; thence along the extreme height of the said mountain to the Painted Rock, on French Broad River; thence along the highest ridge of the said mountain to the place where it is called the Great Iron or Smoky Mountain; thence along the extreme height of the said mountain to the place where it is called the Unicoy or Unaka Mountain, between the Indian towns of Cowee and Old Chota; thence along the main ridge of the said mountain to the southern boundary of this State.

It will be noted that the above description of the eastern boundary of her ceded possessions agrees in general terms with the description ot the western boundary of North Carolina, as given on page 102.

The articles of cession by Georgia describe the area ceded as follows:

The lands situated within the boundaries of the United States, south of the State of Tennessee and west of a line beginning on the west bank of the Chattahouchee River, where the same crosses the boundary line between the United States and Spain; thence running up the said river Chattahouchee and along the western bank thereof to the great bend thereof, next above the place where a certain creek or river, called Uchee (being the first considerable stream on the western side, above the Cussetas and Coweta towns), empties into the said Chattahouchee River; thence in a direct line to Nickajack, on the Tennessee River; thence crossing the last-mentioned river, and thence running up the said Tennessee River and along the western bank thereof to the southern boundary line of the State of Tennessee.

Of the area thus ceded to the General Government, the part lying north of the Ohio was afterwards erected into the "Territory Northwest of the River Ohio," and the balance, lying south of that river, was known as the "Territory South of the River Ohio."

TERRITORY NORTHWEST OF THE RIVER OHIO.

This territory was bounded on the west by the Mississippi and the international boundary, on the north by the boundary line between the United States and the British Possessions, on the east by the Pennsylvania and New York state lines, and on the south by Ohio River. It comprised an area of, approximately, 266,000 square miles. It was made up of claims of different States as follows:

1. Virginia uncontested claims, which consisted of all the territory west of Pennsylvania and north of the Ohio to the forty-first parallel of north latitude, besides her claim, by capture, as far as the northern limits of the land under the crown which had been subject to the jurisdiction of the provinces of Quebec and to Lakes Michigan and Huron.

2. The claim of Connecticut, which extended from the forty-first parallel northward to the parallel of 42° 2′, and from the west line of Pennsylvania to the Mississippi River.

3. The claim of Massachusetts, which extended from the north line of the Connecticut claim above noted to 43° 43′ 12″ north latitude, and from the eastern boundary of New York to the Mississippi.

4. The belt or zone lying north of the Massachusetts claim, extending thence to the Canada line and west to the Mississippi River, was claimed to have been obtained by the treaty of peace of Great Britain, September 3, 1783.

5. At the cession by the state of Virginia, both Massachusetts and New York claimed the Erie purchase of about 316 square miles, which was subsequently bought by Pennsylvania and added to that State.

From this territory were formed the following States: Ohio, Indiana, Illinois, Michigan, Wisconsin, that part of Minnesota east of the Mississippi River, and the northwest corner of Pennsylvania.

In 1787 a bill for its provisional division into not less than three nor more than five States was passed by Congress. In this bill the limits of the proposed States were defined, corresponding in their north and south lines to the boundaries of Ohio, Illinois, and Indiana, as at present constituted. The following gives the text of the clause defining these boundaries:

CONFEDERATE CONGRESS—AN ORDINANCE FOR THE GOVERNMENT OF THE TERRITORY OF THE UNITED STATES NORTHWEST OF THE RIVER OHIO.

* * * * * * *

ARTICLE 5. There shall be formed in the said territory not less than three nor more than five States; and the boundaries of the States, as soon as Virginia shall alter her act of cession and consent to the same, shall become fixed and established as follows, to wit: The western State, in said territory, shall be bounded by the Mississippi, the Ohio, and the Wabash River; a direct line drawn from the Wabash and Post Vincents, due north, to the territorial line between the United States and Canada; and by the said territorial line to the Lake of the Woods and Mississippi. The middle State shall be bounded by the said direct line, the Wabash from Post Vincents to the Ohio, by the Ohio, by a direct line drawn due north from the mouth of the Great Miami to the said territorial line, and by the said territorial line. The eastern State shall be bounded by the last-mentioned direct line, the Ohio, Pennsylvania, and the said territorial line: *Provided, however*, And it is further understood and declared, that the boundaries of these three States shall be subject so far to be altered, that, if Congress shall hereafter find it expedient, they shall have authority to form one or two States in that part of the said territory which lies north of an east and west line drawn through the southerly bend or extreme of Lake Michigan.

Passed July 13, 1787.

The provisions of this bill seem, however, never to have been carried out. A provisional government was instituted in 1788. By act of May 7, 1800, Congress divided this territory into two territorial governments, the divisional line being a meridian passing through the mouth of the Kentucky River and extending thence northward to the Canada border. The eastern portion became the "Territory Northwest of the River Ohio," and the western portion, Indiana Territory.

On November 29, 1802, the State of Ohio, comprising most of the former, was formed and admitted into the Union, while the remnant of it was added to Indiana Territory.

In 1805, all that portion of Indiana Territory lying north of a parallel through the most southerly bend of Lake Michigan and east of a meridian drawn through the same point became the Territory of Michigan. The boundary between these territories was subsequently very much changed, as will appear in the sequel.

By act of February 3, 1809, Indiana Territory was again divided, and the Territory of Illinois was created from the part lying west of the Wabash River and a meridian running through the city of Vincennes, extending thence to the Canada line.

In 1816 Indiana, and in 1818 Illinois, were admitted to the Union as States, each with its boundaries as constituted at present. By the same act the Mississippi River was made the western boundary of the Territory of Michigan, thus making it include all the balance of the original Northwest Territory after the formation of the three States of Ohio, Indiana, and Illinois.

The act of 1834 added to Michigan Territory the land between the Missouri and White Earth Rivers on the west and the Mississippi River on the east.

Wisconsin Territory was formed in 1836 from the portion of Michigan Territory west of the present State of Michigan. On January 26, 1837, Michigan was admitted into the Union, with its present boundaries. In 1838 all that portion of Wisconsin Territory lying west of the Mississippi River and a line drawn due north from its source to the international boundary (that is, all that part which was originally comprised in the Louisiana purchase) was made the Territory of Iowa, and in 1848 Wisconsin was admitted as a State, with its boundaries as at present constituted.

This appears to leave the area which is now the northeastern part of Minnesota, lying east of the Mississippi River and a line drawn due north from its source, without any government until the formation of Minnesota Territory, in 1849.

TERRITORY SOUTH OF THE RIVER OHIO.

The "Territory South of the River Ohio" was bounded on the north by the present northern boundary of Tennessee, on the south by the thirty-first parallel of latitude, on the east by the States of Virginia, North Carolina, South Carolina, and Georgia, and on the west by Mississippi River. The different cessions from the States which made up this region are as follows:

1. The area ceded by North Carolina, which extended from 36° 30′ north latitude southward to 35°, and from the western boundary line of

the present State to the Mississippi River. This is now the State of Tennessee.

2. The area ceded by South Carolina, which formed a narrow belt, 12 or 14 miles in width, lying south of the thirty-fifth parallel, and extending from her western boundary to the Mississippi River. It is doubtful whether under the terms of the original charters South Carolina possessed this strip, or whether it was not included in the possessions of Georgia.

3. The area ceded by Georgia, which comprised most of the region of the present States of Alabama and Mississippi, north of the thirty-first parallel.

Tennessee was admitted as a State in 1796. In 1798 Congress organized the Territory of Mississippi, which was originally a small, rectangular area, bounded on the west by the Mississippi River, on the north by a parallel through the mouth of the Yazoo River; the boundary on the east was the river Chattahoochee, and on the south the thirty-first parallel of north latitude. This area was subsequently enlarged so as to include the whole of what is now Mississippi and Alabama, with the exception of a strip along the Gulf coast, which was at that time claimed by Spain. In 1817 the Territory was divided, and the eastern portion was made into Alabama Territory. Subsequently the two Territories were admitted as States.

LOUISIANA AND THE TERRITORY ACQUIRED FROM MEXICO.

The Louisiana purchase was effected in 1803. In 1804 it was divided into two parts, that portion which now comprises the State of Louisiana being organized as Orleans Territory, while the balance remained as the Louisiana Territory. The State of Louisiana, comprising most of the Territory of Orleans, was admitted to the Union in 1812, and in the same year it was enlarged by the addition of the portion lying between the Mississippi and Pearl rivers, in the southeastern part. In the same year the name of Louisiana Territory was changed to Missouri Territory. In 1819 Arkansaw Territory was created, and in 1836 it was admitted as a State.

In 1820 the State of Missouri was formed from another portion of Missouri Territory, and in 1836 the boundaries of this State were enlarged to their present limits. In 1834, as was stated above, that portion of this Territory lying north of the State of Missouri and east of the Missouri and White Earth rivers was attached to the Territory of Michigan. In 1836 this portion was transferred from the Territory of Michigan to the Territory of Wisconsin. In 1838 it was transferred to the Territory of Iowa. In 1845 the State of Iowa was created, and in 1846 its boundaries were enlarged. In 1849 the remainder of the Territory was transferred to Minnesota Territory. Minnesota was admitted as a State on May 11, 1858, with its present boundaries.

Meantime Texas had been admitted to the Union, and by the treaty of Guadalupe-Hidalgo and the Gadsden purchase, we had acquired from Mexico all the area west of the northern part of Texas and south of the forty-second parallel. Furthermore, our northern boundary had been established on the forty-ninth parallel to the Pacific Ocean.

Out of this great western region were carved the following Territories:

Oregon Territory, which was formed in 1848, and which extended from the parallel of 49° north latitude southward to latitude 42°, and from the Pacific Ocean east to the summit of the Rocky Mountains.

California, which was admitted as a State in 1849, with the same limits which it possesses at present.

Utah Territory, which was formed in 1850, and which extended from the forty-second parallel southward to the thirty-seventh, and from the California boundary line eastward to the Rocky Mountains.

New Mexico, which comprised all the country lying south of Utah to the boundary line of Texas and Mexico, and from the California boundary eastward to the boundary of Texas.

Nebraska Territory, which was formed from Missouri Territory in 1854. It comprised the country from the forty-ninth parallel down to the fortieth and from the Missouri and White Earth Rivers west to the summit of the Rocky Mountains.

Kansas Territory, formed by the same act as the last, comprised the country lying west of Missouri to the boundary of New Mexico and Utah, and from the south boundary of Nebraska to the thirty-seventh parallel.

Indian Territory then had its present limits.

Washington Territory was formed in 1853 from a part of Oregon, its southern boundary being Columbia River and the parallel of 46° north latitude, and its east line being the summit of the Rocky Mountains.

Oregon was admitted as a State in 1857, with its boundaries as at present established. The portion cut off from Oregon Territory was placed under the territorial government of Washington.

Dakota Territory was formed in 1861. As originally formed it comprised all that region between its present eastern and southern boundaries, while its western boundary was the summit of the Rocky Mountains.

The Territory of Nevada was organized from the western portion of the Territory of Utah in 1861. As originally constituted, its eastern line was the meridian of thirty-nine degrees of longitude west from Washington, and its southern boundary was the parallel of thirty-seven degrees of latitude. It was admitted as a State in 1864, its eastern boundary being made the thirty-eighth degree of longitude (approximately the one hundred and fifteenth degree west from Greenwich), while its southern boundary remained the same. In 1866, by act of Congress, the eastern boundary was moved one degree farther to the eastward, placing it upon the thirty-seventh degree of longitude west from Washington, and the triangular portion contained between the former southern boundary, the boundary of California, the Colorado River and the meridian of thirty-seven degrees of longitude was added, thus giving the State its present area and limits.

Colorado Territory was formed in 1861, with the limits of the present State. It was admitted as a State in 1876.

The Territory of Arizona was formed from New Mexico in 1863, being that portion of New Mexico lying west of the thirty-second meridian west of Washington.

In the same year Idaho was formed from parts of Dakota and Washington Territories. As originally constituted it included all the territory lying east of the present eastern limits of Oregon and Washington Territory to the twenty-seventh degree of longitude west of Washington, the latter meridian being its eastern boundary. Its southern boundary was the northern boundary of Colorado and Utah—that is the forty-first and forty-second parallels of latitude

From this Territory was detached, in 1864, the Territory of Montana with its present limits, and in 1868 the Territory of Wyoming, these several changes reducing Idaho to its present dimensions.

CHAPTER III.

THE BOUNDARY LINES OF THE STATES AND TERRITORIES.

MAINE.

The first charter having any relation to the territory comprising th present State of Maine is that granted by Henry IV of France to Pierr du Gast, Sieur de Monts, in 1603, known as the charter of Acadia, whic embraced the whole of North America between the fortieth and forty sixth degrees of north latitude. Under this, several expeditions wer made, and in 1606 it was decided to make a permanent settlement at Po Royal, now Annapolis, Nova Scotia, and no further attempts were mad under this charter to plant colonies within the limits of the prese State of Maine. (*Vide* Charters and Constitutions, p. 771.)

By the first charter of Virginia (*vide* Virginia, p. 94), granted b James I, in 1606, the lands along the coast of North America betwee the thirty-fourth and forty-fifth degrees of north latitude were given to two companies, to one of which, the Plymouth Company, was assigned that part of North America including the coast of New England. The first colony in Maine was planted on the peninsula of Sabine, at the mouth of Kennebec River, now Hunnewell Point, on August 19, 1607, O. S., by George Popham.

James I in 1620 granted a charter to the Plymouth Company, in which may be found the following, viz:

> Wee, therefore * * * do grant ordain and establish that all that Circuit, Continent, Precincts and Limitts in America lying and being in Breadth from Fourty Degrees of Northerly Latitude from the Equnoctial Line, to Fourty eight Degrees of the said Northerly Latitude and in length by all the Breadth aforesaid throughout the Maine Land from Sea to Sea—with all the Seas, Rivers, Islands, Creekes, Inletts, Ports and Havens within the Degrees, Precincts and Limitts of the said Latitude and Longitude shall be the Limitts, and Bounds, and Precincts of the second collony—and to the end that the said Territoryes may hereafter be more particularly and certainly known and distinguished, our Will and Pleasure is, that the same shall from henceforth be nominated, termed and called by the name of New England in America.

Under this grant, given in 1621, the Earl of Stirling claimed that he was entitled to land on the coast of Maine which was afterwards granted to the Plymouth Company, and by direction of James I that company issued a patent to William Alexander, Earl of Stirling,

> For a tract of the main land of New England, beginning at Saint Croix and from thence extending along the sea-coast to Pemquid and the river Kennebeck. (*Vide* Charters and Constitutions, p. 774.)

The heirs of the Earl of Stirling sold this tract to the Duke of York in 1663. (*Vide* Zell's Encyclopædia.)

In 1622 Capt. John Mason and Sir Ferdinando Gorges obtained from the council of Plymouth a grant of the lands lying between the Merrimac and Kennebec Rivers, and extending back to the river and lakes of Canada. This tract was called Laconia, and it included New Hampshire and all the western part of Maine. (*Vide* Whiton's New Hampshire.)

Mason and Gorges, in 1629, by mutual consent divided their territory into two by the river Piscataqua. That part on the east of this river was relinquished to Gorges, who called it Maine. (*Vide* Whiton's New Hampshire.)

The charter of the Plymouth Company was surrendered to the King in the year 1635. (*Vide* Plymouth Colony Laws, p. 333 *et supra.*)

King Charles I, in the year 1639, granted a charter to Sir Ferdinando Gorges, which virtually confirmed the patent given to him by the Plymouth Company in 1622.

The following extract from that charter defines the boundaries:

> All that Parte Purparte and Porcon of the Mayne Lande of New England aforesaid beginning att the entrance of Piscataway Harbor and soe to passe upp the same into the River of Newichewanocke and through the same unto the furthest heade thereof and from thence Northwestwards till one hundred and twenty miles bee finished and from

> Piscataway Harbor mouth aforesaid Northeastwards along the Sea Coasts to Sagadahocke and up the River thereof to Kynybequy River and through the same into the heade thereof and into the Lande Northwestwards untill one hundred and twenty myles bee ended being accompted from the mouth of Sagadahocke and from the period of one hundred and twenty myles aforesaid to crosse over Lande to the one hundred and twenty myles end formerly reckoned upp into the Lande from Piscataway Harbor through Newichewanocke River and also the Northe halfe of the Isles of Shoales togeather with the Isles of Capawock and Nawtican neere Cape Cod as alsoe all the Islands and Iletts lyeinge within five leagues of the Mayne all alonge the aforesaide coasts betweene the aforesaid River of Pascataway and Sagadahocke with all the Creeks Havens and Harbors thereunto belonginge and the Reverconn and Reverconns Remaynder and Remaynders of all and singular the said Landes Rivers and Premisses. All which said Part Purpart or Porcon of the Mayne Lande and all and every the Premisses herein before named Wee Doe for us our heires and successors create and incorporate into One Province or Countie, and Wee Doe name ordeyne and appoynt that the porcon of the Mayne Lande and Premises aforesaid shall forever herefter bee called and named The Province or Countie of Mayne.

In 1664 Charles II granted to the Duke of York, who, the year before, had purchased the territory, which had been awarded to the Earl of Stirling in the division of the country to his heirs, a portion of the present State of Maine, and also certain islands on the coast, and a large territory west of the Connecticut River. (For the boundaries *vide* New York, p. 76 *et seq.*)

In 1674 Charles II made a new grant to the Duke of York, in substantially the same terms as that of 1664, including as before a portion of Maine. (*Vide* New York, p. 77.)

In the year 1677, Ferdinando Gorges, a grandson of Sir Ferdinando Gorges sold and gave a deed of the province of Maine to John Ushur, a merchant, of Boston, for £1,250. In the same year, Ushur gave a deed of the same territory to the governor and company of Massachusetts Bay, who had received a grant from the council of Plymouth in 1628, confirmed by the King in 1629. (*Vide* C. & C., p. 774.)

In 1686 Pemaquid and its dependencies, forming Cornwall County, under the jurisdiction of New York, were annexed to the New England government by a royal order, dated September 19, 1686. (*Vide* Maine Historical Society Collection, vol. 5.)

The charter of Massachusetts Bay of 1629 having been canceled in 1684, in 1691 William and Mary granted a new one, incorporating the provinces of Maine and Acadia, or Nova Scotia, with the colonies of Massachusetts Bay and of Plymouth, into one royal province by the name of the Royal Province of Massachusetts Bay. (*Vide* Mass., p. 54.)

The right of government thus acquired over the district of Maine was exercised by Massachusetts until 1819 when measures were taken to admit Maine as an independent State.

By the treaty of Paris in 1763 the King of France relinquished all claim to that portion of North America which includes the present State of Maine.

The northern and eastern boundaries were settled by the United States and Great Britain. (See p.13, *et seq*).

The western boundary was for a long time a source of contention between Maine and New Hampshire.

New Hampshire having been made a province in 1679, controversies arose concerning the divisional line.

In 1731 commissioners from New Hampshire and from Massachusetts having been appointed, met, but were unable to agree. New Hampshire appealed to the King, and the King ordered that a settlement should be made by commissioners from the neighboring provinces. The board met at Hampton in 1737. The commissioners fixed on—substantially—the present boundary, wording their report as follows:

> Beginning at the entrance of Pascataqua Harbor, and so to pass up the same to the River Newhichawack, and thro' the same into the furthest head thereof, and thence run north 2 degrees west till 120 miles were finished, from the mouth of Pascataqua Harbor, or until it meet with His Majesty's other Governments. (See N. H. Historical Coll., Vol. II.)

This was confirmed by the King, August 5, 1740.

In 1820 Maine was admitted, as an independent State.

Difficulties having arisen about the boundary between Maine and New Hampshire, commissioners were appointed in 1827 from each State to determine the same.

In 1829 the commissioners' report was adopted by each State, and the line then settled upon is as follows, using the language of the commissioners' report, viz:

> The report of the commissioners appointed by His Majesty's order in Council of February 22nd, 1735, and confirmed by his order of the 5th of August, 1740, having established—
>
> "That the dividing line shall pass up through the mouth of Piscataqua Harbor, and up the middle of the river of Newichwannock, part of which is now called the Salmons Falls, and through the middle of the same to the farthest head thereof, &c.," and "that the dividing line shall part the Isle of *Sholes*, and run through the middle of the harbor, between the islands to the sea on the southerly side, &c." We have not deemed it necessary to commence our survey until we arrived north, at the head of Salmon Falls River, which was determined by Bryant, at his survey in 1740, to be at the outlet of East pond, between the towns of Wakefield and Shapleigh. From that point we have surveyed and marked the line as follows, viz:
>
> We commenced at the Bryant Rock, known as such by tradition, which is a rock in the middle of Salmon Falls River, at the outlet of East pond, about six feet in length, three feet in breadth, three feet in depth, and two feet under the surface of the water, as the dam was at the time of the survey, to wit, October 1, 1827; said stone bears south, seventy-one degrees west, three rods and eight links from a large rock on the eastern bank, marked "1827," and bears also from a rock near the mill-dam (marked "H") north, nineteen degrees and thirty minutes west, and distant twelve rods and twenty-one links. At this point the variation of the needle was ascertained to be *nine degrees* west.
>
> From the above stone the line is north seven degrees and forty-one minutes east, one hundred and seventy-eight rods to East pond, and crossing the pond three hundred and eleven rods in width to a stone monument which we erected up on the bank, about three and an half feet high above the surface of the ground, marked N on the

west side and M on the east side, which description applies to all the stone monuments hereinafter mentioned unless they are otherwise particularly described; thence the same course, two hundred and twenty-five rods, to Fox Ridge, and to a stone monument which is placed upon the north side of the road that leads from Wakefield to Shapleigh; thence two hundred rods to Balch's pond; across the pond, one hundred and three and half rods; across a peninsula, thirty-six rods; across a cove, fifty-one rods and seventeen links; across a second peninsula, forty-eight rods; across a second cove, twenty-seven rods, ten links.

Thence three hundred and seventy rods, to the road leading from Newfield to Wakefield and a stone monument, erected on the north side of the same, near Campernell's house; thence north six degrees and ten minutes east, five hundred and ninety rods, to the line of Parsonfield, to a stone monument with additional mark "1828."

At this point the variation of the needle was found to be nine degrees fifteen minutes west. Thence same course five hundred and eleven rods, crossing the end of Province pond to a stone monument on the Parsonfield road, near the house of James Andrews, also with additional mark "1828"; thence north eight degrees and thirty-eight minutes east, two hundred and eight rods, to the old corner-stone of Effingham, about two feet above the ground, and not marked; thence north eight degrees fifty-five minutes east, two hundred and seventy-seven rods, to a large round stone about three feet diameter and two feet high, marked N and M, by the road upon Towles hill; thence north seven degrees fifty-five minutes east, six hundred and thirty-one rods to a stone monument, on the road leading from Parsonfield to Effingham. At this point the variation of the needle was found to be 9 degrees thirty minutes west. Thence north five degrees two minutes east, seven hundred thirty-four to a pine stump, upon a small island in Ossipee River at the foot of the falls; thence north ten degrees east, thirty rods, to a stone monument, on the north side of the new road from Porter to Effingham; thence the same course, five hundred fifty-eight rods, to the top of Bald Mountain; thence same course, three hundred sixteen rods, to the top of Bickford Mountain; thence same course one hundred and ninety-three rods, to a stone monument, on the north side of the road, leading from Porter to Eaton.

At this point the variation of the needle was found to be nine degrees forty-five minutes west; thence north eight degrees five minutes east, seven hundred and forty-four rods, to Cragged Mountain; thence same course, sixty-seven rods, to the corner of Eaton; thence same course, seven hundred eighty-seven and an half rods, to the corner of Conway; thence same course, six hundred ten and an half rods, to a stone monument, on the south side of the road, leading from Brownfield to Conway Center; thence north eight degrees east, eight hundred seventy-one rods, to a stone monument on the south side of the road leading from Fryeburg Village to Conway. At this point the variation of the needle was found to be ten degrees west; thence same course, four rods, to a stone monument on the north side of the same road; thence north eight degrees fifteen minutes east, one hundred two rods, to Saco River; thence same course, eighteen rods, across said river; thence same course, six hundred forty-four rods, to a stone monument on the road leading to Fryeburg Village, on the north side of the river.

This monument is marked as before described, and is about eight feet high above the ground; thence same course, one hundred forty-two rods, to Ballard's Mill Pond; thence same course, sixty-one rods, six links, across said pond; thence same course, three hundred forty-four rods, to a stone monument on the east side of Chatham road; thence same course, six hundred ninety rods, to Kimball's Pond; thence same course, one hundred sixty-six rods, across said pond; thence same course, sixty rods, to a stone monument on the meadow.[1] Thence same course, nine hundred forty rods, to the corner of Bradley and Eastman's grant; thence same course, six hundred and ninety rods, to a stone monument on the east side of the Cold River road. This stone is marked as

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[1] From this point the line was resurveyed in 1858, *vide* p. 44.

before described, but is not more than two feet above the ground. Thence same course, one thousand five hundred forty rods, to the corner of Warner and Gilman's location, a pile of stones. At this point the variation of the needle was found to be ten degrees twenty-three minutes west; thence same course, four hundred and fifty rods, to top of Mount Royce; thence same course, eight hundred ninety-eight rods, to Wild River; thence same course, eight rods, across said river; thence same course, seven hundred sixty-five rods, to a stone monument on the north side of the road leading from Lancaster to Bethel; thence same course, one hundred rods, to Androscoggin River; thence same course, eighteen rods, across said river; thence north eight degrees ten minutes east, four thousand one hundred sixty-two rods, across ten streams, to Chickwalnepg River; thence same course, two thousand five hundred rods, to a stone monument on the north side of the road leading from Errol to Andover. This stone is marked "N. H." and "M.," thence same course two hundred ten rods to Cambridge River, thence same course eight rods across said river, thence same course five hundred sixty-seven rods to Umbagog Lake, thence same course thirty-four rods across a cove of the same, thence same course ten rods across a peninsula of the same, thence same course two hundred twenty-five rods across a bay of said lake, thence same course two hundred six rods across a peninsula of the same, thence same course one thousand one hundred sixty-five rods across the north bay of said lake to a cedar post marked "N." "M.," thence north eight degrees east seven hundred fourteen rods to Pond brook; thence same course two hundred twenty-five rods to a stone monument on the south side of the Margallaway River, thence same course ten rods across said river, thence same course one hundred sixty-two rods to a spruce, corner of the college grant, thence same course two hundred sixty-four rods to Margallaway River a second time. At this point the variation of the needle was found to be eleven degrees forty-five minutes west; thence same course ten rods across said river, thence same course two hundred and ninety rods to same river a third time, thence same course ten rods across said river to a monument made with three stones on the north side of said river, about two feet high and not marked, thence same course four hundred forty-four rods to corner of township number five, in second range, in Maine, thence same course one thousand eight hundred six rods to the north corner of the same township, thence same course four hundred and sixty rods to a branch of Little Diamond River, thence same course three hundred fifty rods to another branch of the same, thence same course two thousand one hundred twenty rods to a branch of the Margallaway River, thence same course three hundred thirty-two rods to another branch of the same, thence same course four hundred rods to a steep mountain called Prospect Hill, thence same course nine hundred and twenty rods to Mount Carmel, sometimes called Sunday Mountain, thence same course four hundred rods to a perpendicular precipice, thence same course five hundred and forty rods to a branch of Margalloway River, thence same course two hundred and sixty rods to a branch of the same, thence same course three hundred forty-six rods to a second steep precipice, thence same course one hundred eighty-six rods to a branch of Margallaway River, thence same course two hundred forty-two rods to another branch of same river, thence same course seventy-eight rods to a beaver pond, thence same course one hundred twenty-six rods to a yellow birch tree on the highlands which divide the waters that run south from those that run into the St. Lawrence, being the northern extremity of the line and one hundred and twelve miles two hundred and thirty-three rods from the head of Salmon Falls River.

Found said tree marked on the east side "M. E. 1789," and on the west "N. H. N. E.;" also "M. 54." To these marks we added "N. H.," "N. E.," and "M. E.," "1828," "E. H.," "A. M. M.," "1828," and stones were piled round the same and marked.

The whole course of the line from the Androscoggin River was re-marked by spotting the old marked trees and crossing the spots and marking others in the course. And the line as above survey and described we agree to be the true boundary line of said States. And the above-described marks and monuments we establish to designate the same, and that the said line hereafter remain the boundary line between the States, unless the legislature of either State shall, at the first session after the execution of this agreement, disapprove of the same.

WILLIAM KING,
RUFUS McINTIRE,
Commissioners of Maine.
ICHABOD BARTLETT,
JOHN W. WEEKS,
Commissioners of New Hampshire.

NOVEMBER 13, 1828.

The legislature of Maine approved of the commissioners' report February 28, 1829, and requested the governor to issue his proclamation accordingly.

The same action was taken by the legislature of New Hampshire, July 1, 1829.

(For Report of Commissioners, see Laws of Maine, 1828–'9, under head of Resolves of the Ninth Legislature of the State of Maine, pages 39–43.)

Between 1828 and 1858, considerable portions of the amost unbroken forests through which the line of 1827–'28 was marked were cleared. Extensive forest fires often swept large tracts of this territory, and, as a consequence, the marks of the 1827–'28 survey for a distance of nearly eighty miles—which by that survey was mainly fixed by blazed trees,—only *seven* stone posts having been set in this distance—were obliterated, so that there remained scarcely a vestige of the original line. The lands having become valuable, and litigation in many cases being imminent, the legislatures of the two States in 1858 provided by enactment for another survey from Fryeburg to the Canada line—which was made the same year. The line as then surveyed is as follows, viz:

Commencing at an iron post[a] situated on the line run in accordance with the "Treaty of Washington, of August 9, 1842," as the boundary between the United States and the province of Canada, at the corners of the States of Maine and New Hampshire. On the south face of said post are the words "Albert Smith, U. S. Comssr."; on the north face, "Lt. Col. I. B. B. Eastcourt, H. B. M. Comssr."; on the west face, "Boundary, Aug. 9, 1842"; on the east face, "Treaty of Washington." To the marks are added on the southern half of the west face, "H. O. Kent." A large flat stone was placed on the southern face of the monument and marked "1858—N. H., Me.," on either side of a line cut in said stone bearing the direction of the State's line, viz, south, 8 degrees west.

From this point the line is south 8 degrees west, 17 rods, 7 links to a large yellow birch stub, the northern terminus of the former survey; thence 126 rods to a beaver pond; thence 78 rods to the northwesterly branch of the Margallaway, known as Kent River; thence 242 rods to another branch of the Margallaway; thence 186 rods to a certain steep precipice perpendicular on its southern face; thence 346 rods to a branch of the Margallaway River; thence 260 rods to another branch of the same; thence 540 rods to a precipice, the southern side of Mount Abbott; thence 400 rods to the summit

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[a] The position of this post is given in Hitchcock's Geological Survey of New Hampshire, as follows, viz, latitude, 45° 18′ 23″.33; longitude, 71° 5′ 40″.5.

of Mount Carmel; thence 920 rods, and across four streams, to the summit of Prospect Hill.

On this distance we marked a yellow birch tree "H. O. Kent, September 20, 1858," and the names of the remainder of the party; thence 400 rods to another branch of the Margallaway; thence 332 rods to the Little Margallaway River; thence 2,120 rods across Bosebuck Mountain to a branch of said river. On this distance at the northwest corner of township No. 5, range 3, in Maine, we marked a white birch tree, "N. H. M.," and on its north and south sides, "IV, III." Thirty rods from the summit of Bosebuck Mountain, and on its northern slope, we erected a stone monument marked "N. M."; thence 350 rods to the Little Diamond River or Abbott Brook; thence 460 rods to the northwest corner of township No. 5, range 2, in Maine. On this distance we found an ancient yellow birch tree marked "1789-35, M." To these marks we added "1858"; thence 1,806 rods to the southwest corner of the same township. On this distance, at the northeast corner of Dartmouth College, second grant in N. H., we marked a large yellow birch tree "Me., J. M. W., 1858; N. H., H. O. K."; thence, and across an open bog, 444 rods to the north bank of the Margallaway River, to a white maple tree marked "N. H. M."; thence 10 rods across said river to a large pine tree marked "M." "N. H."; thence and across a second open bog 290 rods to the same river and to a large elm stub; thence 10 rods across said river; thence 264 rods to a spruce post marked "M." "N. H.", "W. L.", "D. C.", being the southeast corner of Dartmouth College, second grant; thence 162 rods to the Margallaway River; thence 10 rods across said river to a stone monument on its southerly side, standing about 3 feet above the ground and marked "M." "N. H."; thence to the original line tree nearest to the clearing of the home farm of Z. F. Durkee, esq. *The course of the line the entire distance from the iron post at the national boundary to this point bears south eight degrees west;* thence across said clearing, the old line marks being gone, south 11 degrees and 30 minutes west, 168 rods, to the old crossed trees in the woods south of Pond Brook; thence from Pond Brook south eight degrees west, 714 rods to the north bog of Umbagog Lake and to a cedar tree marked "M." "N." To this we added "1858."

On this distance near the corner of Errol and Wentworth's location, which is a cedar post in a pile of stones, we marked a maple tree "M. 1858," "N. H. 1858"; thence south ten degrees and thirty minutes west 1,165 rods, across the north bay of said lake to the old marked trees on the southern shore; thence south eight degrees west 206 rods across the peninsula to a cedar tree marked "M." "N. H." A large stone, also, on the lake shore was marked "M," "N. H."; thence same course 225 rods, across a bay of said lake; thence same course 10 rods, across a peninsula; thence same course 34 rods across a cove; thence same course 567 rods to Cambridge River; thence same course 8 rods, across said river to a white maple stub; thence same course 210 rods to a stone monument on the north side of the road leading from Andover, Me., to Colebrook, N, H.; thence same course to the north edge of the burnt land in Grafton and Success; thence south 11 degrees west across ten streams and the Chickwalmpy River, or Silver Stream, to the old line trees bearing the crosses, easterly of the south end of Success Pond; thence on the same course south 10 degrees west following the old mark to an ash tree bearing the original cross, standing a few rods north of the house of the late Daniel Ingalls, in Shelburne; thence south 11 degrees west to a stone monument, by the road on the north side of the Androscoggin River, and to the north bank of said river, the whole distance from the stone monument near Umbagog Lake to the north bank of the Androscoggin River, being 6,662 rods; thence south 11 degrees west 18 rods across said river; thence same course 100 rods, crossing the track of the Grand Trunk Railway to a stone monument on the north side of the road leading from Lancaster, N. H., to Bethel, Me.; thence same course, 765 rods to a hemlock tree on the south bank of Wild River; thence south 66 degrees 30 minutes west 34 rods on an offset of the old survey along said south bank to the old line trees; thence following the old line trees south 11 degrees west, passing the southeast corner of Shelburne, 898 rods to the top of Mount Royce, the whole distance being 1,881 rods. One mile north of the summit of Mount Royce we marked a beech tree "N. H." "M.," 1858; thence to a large stone marked "N. H." "Me."; thence south 10 degrees 15 minutes west to a stone monument on the east side of the Cold River road. On this distance at the foot of the first precipice on the northern face of Mount Royce a white-birch tree was marked "1858." Further on and east of a bare ledge a white-birch tree was marked "1858," and near it, on the line, a pile of stones was erected. At the first clearing, near the north end of a stone fence, a large stone was marked "M." "N. H."; thence along a stone fence and across a road through a piece of new growth and again crossing the road; then following another stone fence on the east side of the road, passing through a field and by the end of another stone fence; then crossing a road near the west end of a bridge over Cold River; then following the valley of that stream and crossing it six times; then crossing another road, where we placed a stone monument; then through a field, striking an old stump and pile of stones, shown as the old line and passing between a house and barn, and through the western edge of a grove of trees to the stone monument near the house of Mr. Eastman, the whole distance being 1,190 rods; thence 1,630 rods to a stone monument standing in the meadow 60 rods north of the north shore of Kimball's pond, in Fryeburg.

But as the towns of Fryeburg and Stowe have erected no durable monument on the State's line at their respective corners, we deemed it advisable, under our instructions, to proceed so far south as at least to pass the said corner and to complete the work at some well-defined monument of the old survey.

This course bore from the monument to and across an open bay south 12 degrees west; thence on the old trees south 9 degrees west 100 rods; thence on the old line south 10 degrees 30 minutes west to a stone monument erected by us near the house of Jonnet Clay, in Chatham, and on the north side of the road leading from Stowe to Chatham Corners; said monument is marked "M." "N. H." 1858; thence on the old line south 11 degrees west to the road leading from North Fryeburg to Chatham, at which point we placed a stone monument; thence south 11 degrees west to the northwest corner of Fryeburg, being a stake in a pile of stones in a piece of low ground, southerly of the house of Captain Bryant, and to the old monument, 60 rods north of Kimball's pond. On the bank north of said corner, on the south side of the road, and near Captain Bryant's house, we placed a stone monument marked "M." "N. H. 1858."

The different courses laid down in the foregoing report are the bearings of the compass in 1858 when placed on the line established in 1828. (See Legislative Journal of New Hampshire, 1859, pages 764–767.)

In 1874 the line between Maine and New Hampshire was resurveyed and marked. (*Vide* Hitchcock's Geology of New Hampshire, Vol. I, p. 173.)

NEW HAMPSHIRE.

The first charter of Virginia, granted in 1606, included the territory of the present State of New Hampshire (*vide* p. 38), as did the charter of New England, granted in 1620 (*vide* p. 39), and the grant to Capt. John Mason and Sir Ferdinando Gorges of 1622 (*vide* p. 39).

The president and council of New England made a grant to Capt. John Mason in 1629 as follows, viz:

* * * * * * *

> All that part of the main land in New England lying upon the sea coast, beginning from the middle part of Merrimack River, and from thence to proceed northwards along the sea-coast to Piscataqua River, and so forwards up within the said river and to the furthest head thereof, and from thence northwestwards until three score miles be finished from the first entrance of Piscataqua River and also from Merrimack through the said river and to the furthest head thereof, and so forward up into the lands westward until three score miles be finished, and from thence to cross overland to the three score miles, and accompted to Piscataqua River, together with all islands and islets within 5 leagues distance of the premises and abutting upon the same, or any part or parcel thereof, &c., * * * which said portions of lands * * * the said Capt. John Mason, with the consent of the president and council, intends to name *New Hampshire.* * * *

In 1635 the grant of 1629 was confirmed by a supplementary grant, of which the following is an extract, viz:

> All that part of the Mayn Land of New England aforesaid, beginning from the middle part of Naumkeck River, and from thence to proceed eastwards along the Sea Coast to Cape Anne, and round about the same to Pischataway Harbour, and soe forwards up within the river Newgewanacke, and to the furthest head of the said River and from thence northwestwards till sixty miles bee finished, from the first entrance of Pischataway Harbor, and alsoe from Naumkecke through the River thereof up into the land west sixty miles, from which period to cross over land to the sixty miles end, accompted from Pischataway, through Newgewanacke River to the land northwest aforesaid; and alsoe all that the South Halfe of the Ysles of Sholes, all which lands, with the Consent of the Counsell, shall from henceforth be called New-hampshyre. And alsoe ten thousand acres more of land on the southeast part of Sagadihoc at the mouth or entrance thereof—from henceforth to bee called by the name of Massonia, &c. * * *

After the death of Capt. John Mason (in December, 1635), the affairs of the colony coming into bad condition, they sought the protection of Massachusetts in 1641 and enjoyed it till 1675, when Robert Mason, a grandson of John Mason, obtained a royal decree, under which, in 1680, a colonial government was established. But no charter was given to the colony, and its government was only continued during the pleasure of the King. The following is an extract from the commission, or decree, issued by the King in 1680:

> Province of New Hampshire, lying and extending from three miles northward of Merrimack River or any part thereof into ye Province of Maine.

In the year 1690 the province of New Hampshire was again taken under the jurisdiction of Massachusetts Bay, but was again separated in 1692.

[For a history of the boundary between New Hampshire and Maine, *vide* Maine, p. 41.]

The controversy already referred to arising between the provinces of New Hampshire and Massachusetts Bay not only involved the settlement of the boundary between New Hampshire and Maine, but also that between New Hampshire and Massachusetts, and, as before stated (*vide* Maine, p. 41), the commissioners appointed by the two provinces having been unable to agree, New Hampshire appealed to the King, who ordered that the boundaries should be settled by a board of commissioners appointed from the neighboring colonies.

The board met at Hampton in 1737, and submitted a conditional decision to the King, who in 1740 declared in council as follows, viz:

> That the northern boundary of the province of Massachusetts be a similar curve line pursuing the course of the Merrimac River, at three miles distance, on the north side thereof, beginning at the Atlantic Ocean and ending at a point due north of Pautucket Falls, and a straight line drawn from thence, due west, till it meets with His Majesty's other Governments. (*Vide* Vermont State Papers, Slade, p. 9.)

New Hampshire claimed her southern boundary to be a line due west from a point on the sea three miles north of the mouth of Merrimac River. Massachusetts claimed all the territory three miles north of any part of Merrimac River. The King's decision gave to New Hampshire, a strip of territory more than fifty miles in length and of varying width, in excess of that which she claimed. This decree of the King was forwarded to Mr. Belcher, then governor of both the provinces of New Hampshire and Massachusetts Bay, with instructions to apply to the respective assemblies to unite in making the necessary provisions for running and marking the line conformable to the said decree, and if either assembly refused, the other was to proceed *ex parte*. Massachusetts Bay declined complying with this requisition. New Hampshire, therefore, proceeded alone to run and mark the line.

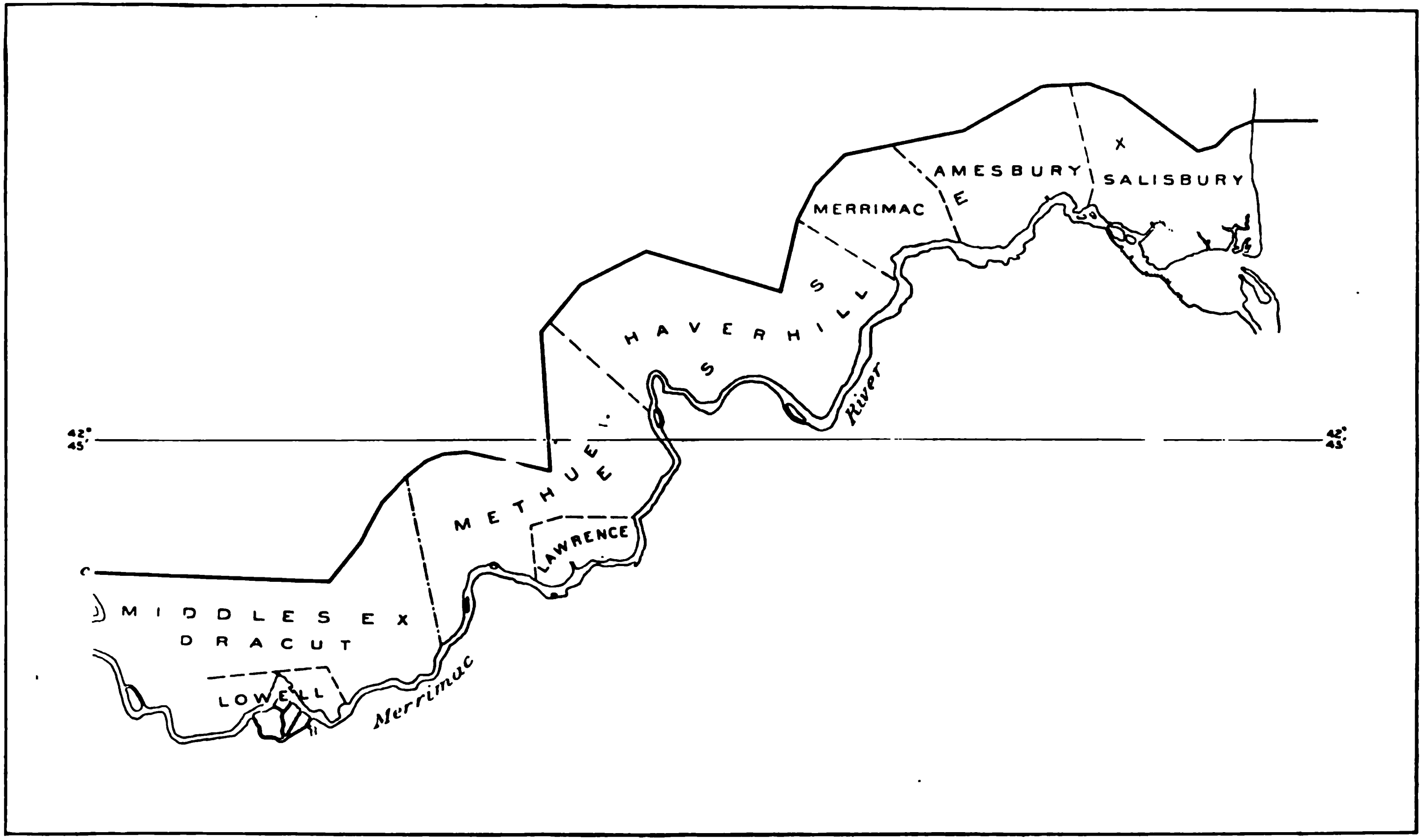
George Mitchel and Richard Hazen were appointed by Belcher to survey and mark the line. Pursuant to this authority, in the month of February, 1741, Mitchel ran and marked the line from the sea-coast about three miles north of the mouth of the Merrimac River to a point about three miles north of Pawtucket Falls, and Hazen, in the month of March following, ran and marked a line from the point, three miles north of Pawtucket Falls, across the Connecticut River, to the supposed boundary line of New York, on what he then supposed to be a due west course from the place of beginning. He was instructed by Governor Belcher to allow for a westerly variation of the needle of ten degrees. (*Vide* New Hampshire Journal H. R., 1826.)

The report of the surveyors has not been preserved, but the journal of Hazen has been found, and is published in the New England Historical and Genealogical Register, July, 1879.

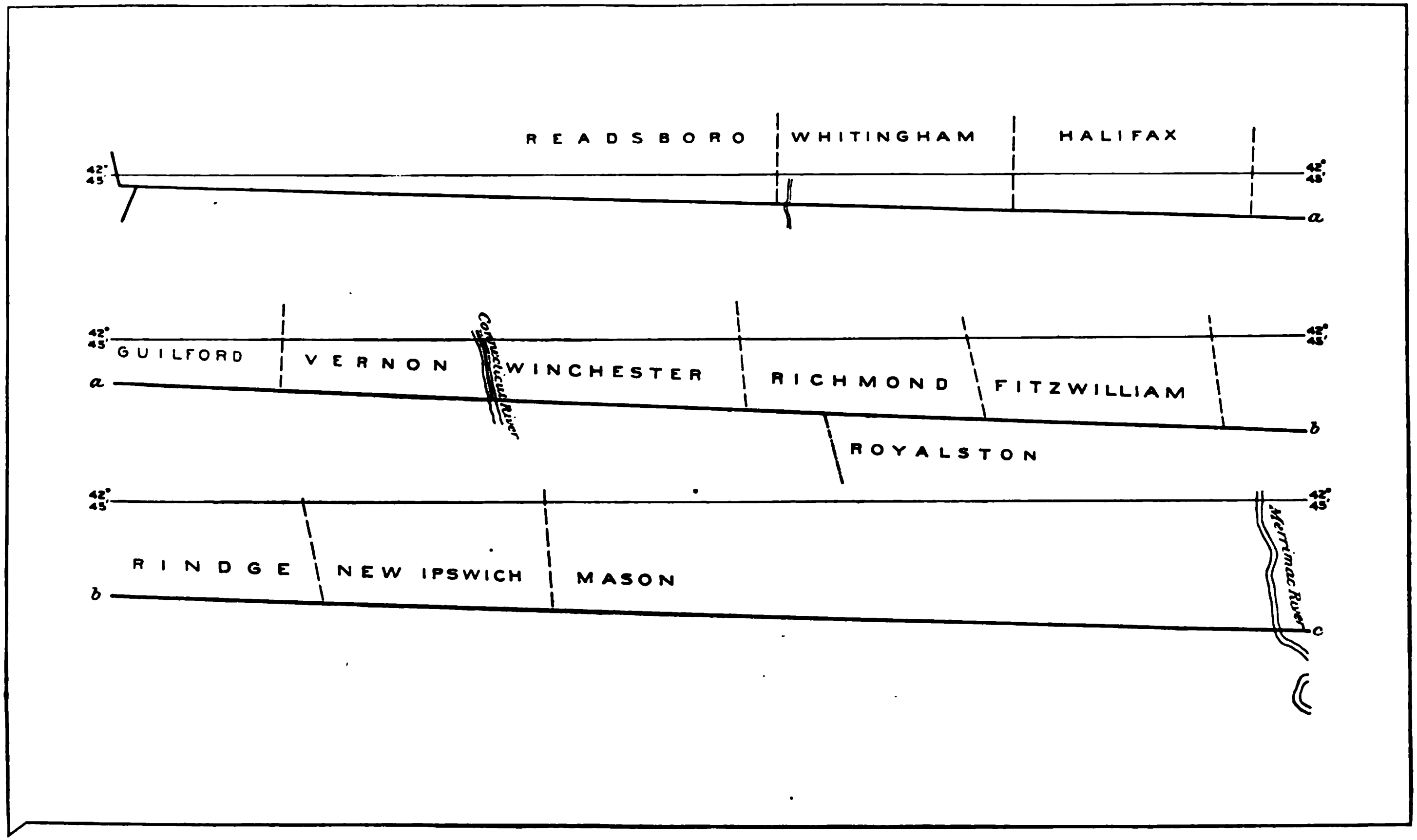
Subsequent investigation has proved that this line was not run on a due west course, the allowance for the westerly variation of the needle being quite too large, throwing the line north of west.

This mistake seems to have been known previous to the Revolution. In 1774 calculations were made by George Sproule, founded upon actual surveys and accurate astronomical observations, from which he determined that Hazen's line was so far north of west as to lose to the State of New Hampshire quite a large tract of land. (*Vide* New Hampshire Journal H. R., 1826.)

In 1825 commissioners were appointed by the States of New Hamp-



NORTH BOUNDARY OF MASSACHUSETTS.



NORTH BOUNDARY OF MASSACHUSETTS

shire and Massachusetts to ascertain, run, and mark the line between the two States, under the proceedings of which New Hampshire asserted her claim to a due west line, conformable to the decree of 1740, it being apparent by a survey made by the commissioners that the original line was north of west. This the Massachusetts commissioners refused to do, alleging that they were only empowered to ascertain and mark the original line.

On March 10, 1827, the legislature passed a resolution providing for the erection of durable monuments to preserve the boundary line between the States of Massachusetts and New Hampshire, as the same had been run and ascertained by the commissioners, and monuments were erected accordingly. (*Vide* Resolves of Massachusetts, 1827.)

In 1885 the joint commission appointed by the States of New Hampshire and Massachusetts re-ran and marked the curved portion of the boundary, following the course of Merrimac River, changing it only to a trifling extent. This commission was, however, unable to agree upon the boundary west of Pawtucket Falls. This matter dragged along until finally in 1894 this commission, together with a commission representing Vermont, agreed to maintain the Hazen line, and this line was re-traced and re-marked from Pawtucket Falls to the northwest corner of Massachusetts.

Under the decree of the King of 1740 the province of New Hampshire claimed jurisdiction as far west as the territory of Massachusetts and Connecticut extended, thus including the present State of Vermont. New York claimed all the country west of the Connecticut, under the charters of 1664 and 1674 to the Duke of York. A bitter controversy ensued. The following papers serve to throw some light on the matter:

Letter from the Governor of New Hampshire to the Governor of New York.

PORTSMOUTH, *November 17, 1749.*

* * * I think it my duty * * * to transmit to your excellency the description of New Hampshire as the King has determined it in the words of my commission. * * * In consequence of His Majesty's determination of the boundaries between New Hampshire and Massachusetts, a surveyor and proper chainmen were appointed to run the western line from 3 miles north of Pautucket Falls, and the surveyor upon oath has declared that it strikes Hudson's River about 80 poles north of where Mohawk's River comes into Hudson's River.

* * * * * * *

B. WENTWORTH.

(See State Papers of Vermont, Slade, 1, page 10.)

The following is a description of the bounds of New Hampshire given to Governor Benning Wentworth, of province of New Hampshire, by George II, July 3, 1741:

George the Second, by the Grace of God, of Great Britain, France, and Ireland King, Defender of the Faith, &c.

To our trusty and well-beloved Benning Wentworth, esqr., greeting:

Know you that we, reposing especial trust and confidence in the prudence, courage, and loyalty of you, the said Benning Wentworth, out of our especial grace, certain knowledge, and meer motion, have thought fit to constitute and appoint, and by these presents do constitute and appoint you, the said Benning Wentworth, to be our governor and commander-in-chief of our province of New Hampshire, within our dominions of New England in America, bounded on the south side by a similar curve line pursuing the course of Merrimac River at three miles distance, on the north side thereof, beginning at the Atlantick Ocean and ending at a point due north of a place called Pautucket Falls, and by a straight line drawn from thence due west cross the said river 'till it meets with our other Governments. * * *

Given at Whitehall July the 3rd, in the 15th year of His Majesty's reign.

(See Documentary History of N. York, vol. 4, page 331.)

The question of the right of territory was submitted to the King, who in 1764 made the following decree:

ORDER IN COUNCIL FIXING THE BOUNDARY BETWEEN NEW YORK AND NEW HAMPSHIRE.

[L. S.] AT THE COURT AT ST. JAMES,
The 20th day of July, 1764.

Present: The King's Most Excellent Majesty; Lord Steward, Earl of Sandwich, Earl of Halifax, Earl of Powis, Earl of Hilsborough, Mr. Vice Chamberlain Gilbert Eliot, Esqr., James Oswald, Esqr., Earl of Harcourt.

Whereas there was this day read at the Board a report made by the right honorable the lords of the committee of council for plantation affairs, dated the 17th of this instant, upon considering a representation from the lords commissioners for trade and plantations, relative to the disputes that have some years subsisted between the provinces of New Hampshire and New York, concerning the boundary line between those provinces, His Majesty, taking the same into consideration, was pleased with the advice of his Privy Council to approve of what is therein proposed, and doth accordingly hereby order and declare the western banks of the river Connecticut, from where it enters the province of the Massachusetts Bay, as far north as the forty-fifth degree of northern latitude, to be the boundary line between the said two provinces of New Hampshire and New York. Whereof the respective governors and commanders in chief of His Majesty's said provinces of New Hampshire and New York for the time being, and all others whom it may concern, are to take notice of His Majesty's pleasure hereby signified and govern themselves accordingly.

WM. BLAIR.

(*Vide* Documentary History of New York, vol. 4, p. 355.)

Notwithstanding this decree of the King, controversy, attended with violence, was kept up for many years; but the line was finally accepted and now forms the boundary line between the States of New Hampshire and Vermont.

The northern boundary of New Hampshire was settled by the United States and Great Britain. (*Vide* p. 18 *et seq.*)

It is as follows, viz:

Commencing at the "Crown Monument," so called, at the intersection of the State of New Hampshire, Maine, and the Province of Quebec, in latitude 45° 18′ 23″.33, longitude 71° 5′ 40″.5, thence in an irregular line to Hall's Stream, thence down the same to the northeastern corner of Vermont, in latitude 45° 0′ 17″.58, longitude 71° 30 34″.5. (*Vide* Hitch. Geology of New Hampshire.)

VERMONT.

The grants from King Henry, of France, of 1603, and King James, of England, of 1606, both included that territory which forms the present State of Vermont. It was also included in the charter of New England of 1620.

In the grants to the Duke of York, in 1664 and 1674, all the territory between the Connecticut and Delaware Rivers was included. New York, therefore, claimed jurisdiction of the territory now known as Vermont. Massachusetts, however, at an early period, having made claim to the tract west of the Connecticut River, now a portion of that State, by the interpretation of her charter, claimed the greater part of the same territory. By the terms of the charter of Massachusetts Bay, of 1629, that colony was granted all the lands—

> Which lye and be within the space of Three English myles to the northward of the saide River called Monomack alias Merrymack, or to the norward of any and every Parte thereof.

Under this clause Massachusetts Bay claimed that her jurisdiction extended 3 miles north of the farthest part of the Merrimac River, which would embrace a large portion of New Hampshire and Vermont. New Hampshire contested this claim, and after several years' controversy was more than sustained by a decision of the King in 1740. New Hampshire in her turn claimed the territory of Vermont, on the ground that Massachusetts and Connecticut, having been allowed to extend their boundaries to within 20 miles of the Hudson River, her western boundary should go equally as far, and contended that the King's decree of 1740 left that fairly to be inferred; also, that the old charters of 1664 and 1674 were obsolete.

By a decree of the King, however, the territory west of the Connecticut River, from the 45th parallel of north latitude to the Massachusetts line, was declared to belong to the province of New York. (*Vide* New Hampshire, p. 50.)

As most of the settlers of Vermont were from New Hampshire, this decision of the King caused great dissatisfaction, and the Revolution found Vermont the scene of conflicting claims, and the theatre of violent acts, culminating, in some instances, in actual bloodshed.

On January 15, 1777, Vermont declared herself independent and laid claim to the territory west as far as Hudson River, and from its source north to the international boundary, including a tract along the west shore of Lake Champlain. A part of New Hampshire, also, at one time, sought a union with Vermont.

In 1781 Massachusetts assented to her independence. She adjusted her differences with New Hampshire in 1782, but eight years more passed before New York consented to her admission into the Union.

In 1791 Vermont was admitted as an independent State, but was required to restrict her boundaries to their present extent.

The act of New York, of March 6, 1790, giving her consent to the admission of Vermont, defines her boundaries. (*Vide* Slade's Vermont, p. 507.)

The northern boundary was settled by the United States and Great Britain by the treaty of Washington, in 1842. (*Vide* p. 18.)

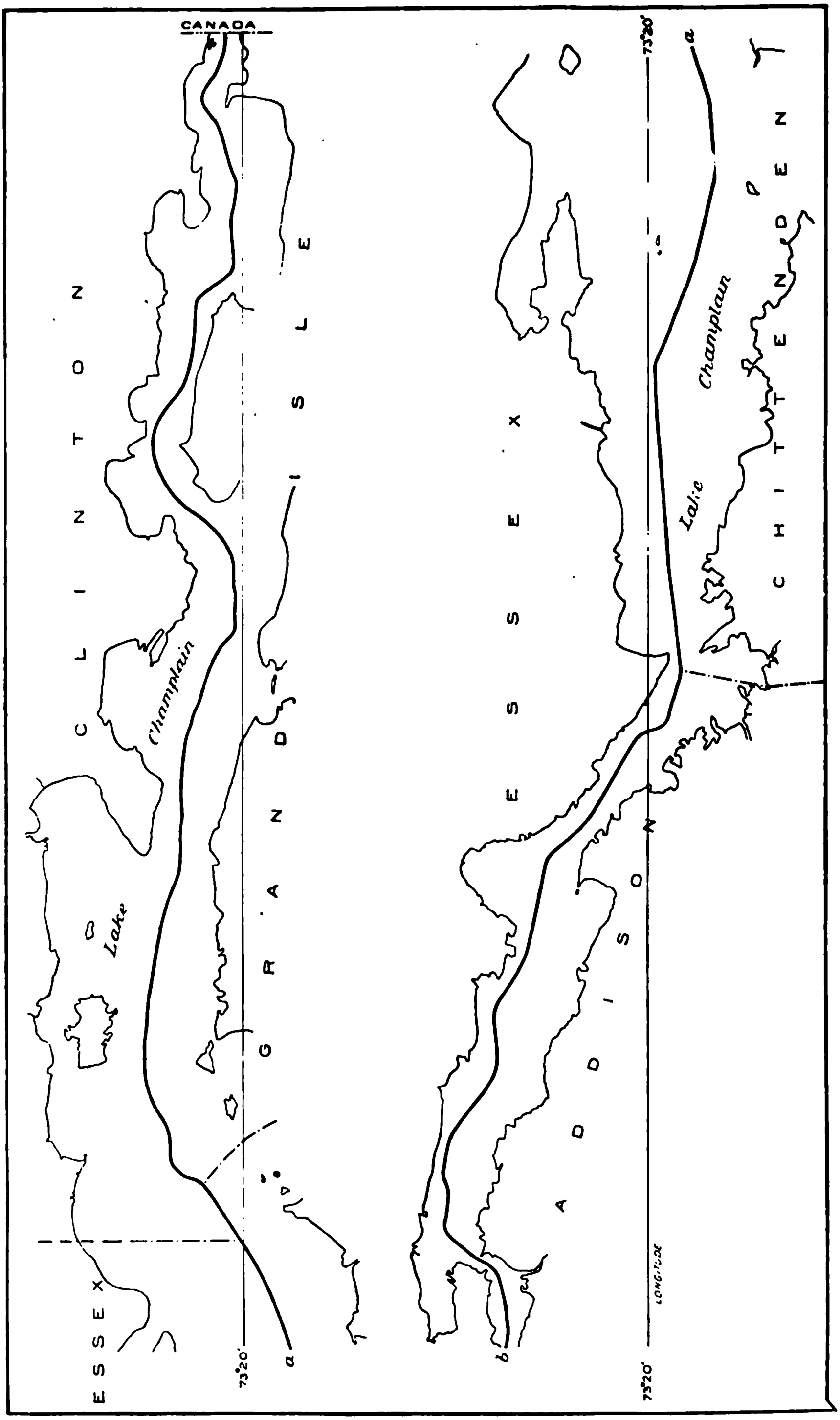
The eastern boundary is low-water mark on the west bank of the Connecticut River. (*Vide* New Hampshire, p. 50.)

The southern boundary was settled by the decree of 1740. (*Vide* New Hampshire, p. 48.)

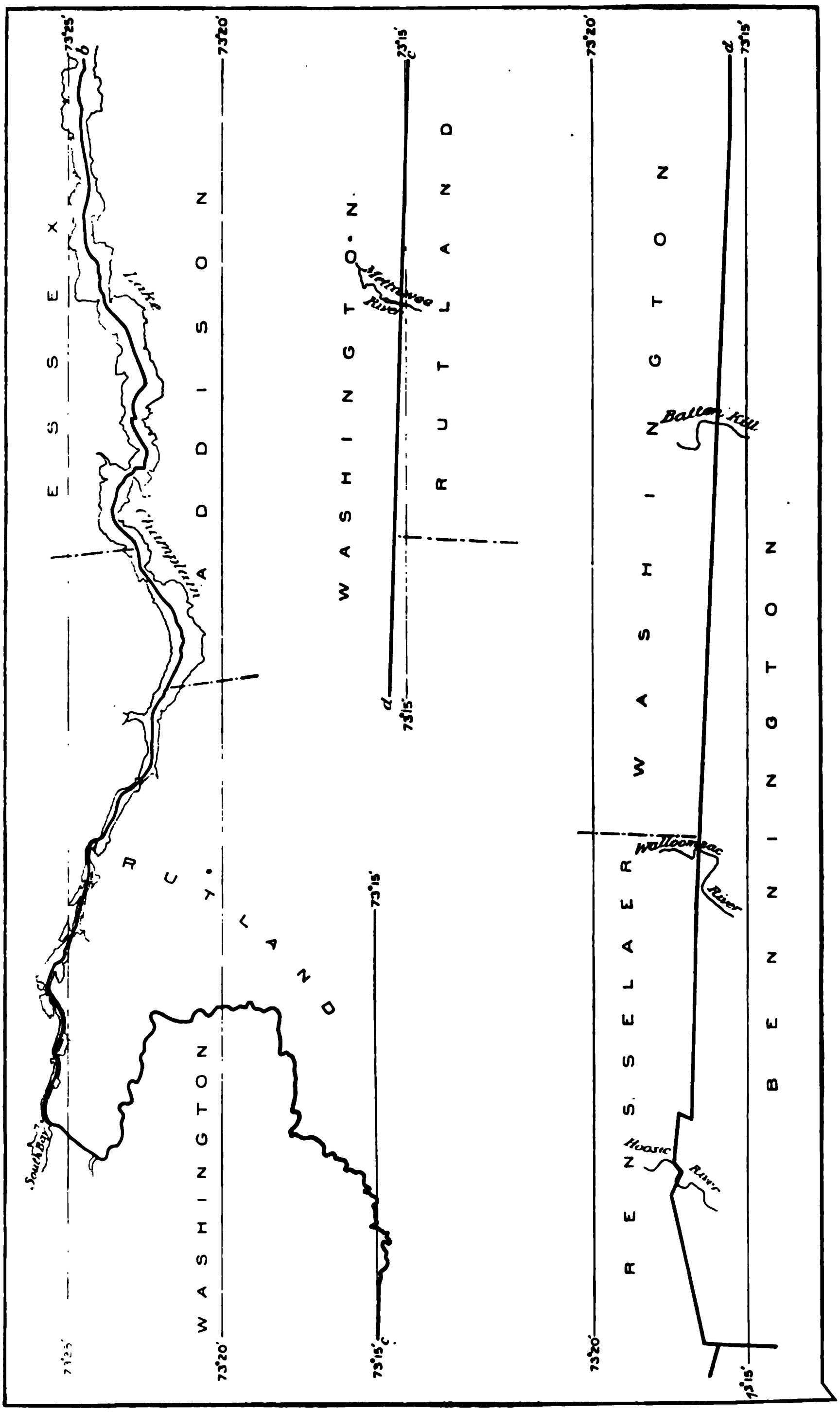
The line between Vermont and New York was surveyed and marked by commissioners from the two States in 1814, and is as follows, viz:

Beginning at a red or black oak tree, the northwest corner of Massachusetts, and running north 82° 20′ west as the magnetic needle pointed in 1814, 50 chains, to a monument erected for the southwest corner of the State of Vermont, by Smith Thompson, Simon De Witt, and George Tibbitts, commissioners on the part of New York, and Joseph Beeman, jr., Henry Olin, and Joel Pratt second, commissioners on the part of the State of Vermont, which monument stands on the brow of a high hill, descending to the west, then northerly in a straight line to a point which is distant 10 chains, on a course, south 35 degrees west, from the most westerly corner of a lot of land distinguished in the records of the town of Pownal, in the State of Vermont, as the fifth division of the right of Gamaliel Wallace, and which, in the year 1814, was owned and occupied by Abraham Vosburgh; then north 35 degrees east to said corner and along the westerly bounds of said lot, 30 chains to a place on the westerly bank of Hasick River, where a hemlock tree heretofore stood, noticed in said records as the most northerly corner of said lot; then north 1 degree and 20 minutes west, 6 chains to a monument erected by the said commissioners, standing on the westerly side of Hasick River, on the north side of the highway leading out of Hasick into Pownal, and near the northwesterly corner of the bridge crossing said river; then north 27 degrees and 20 minutes east, 30 chains, through the bed of the said river, to a large roundish rock on the northeasterly bank thereof; then north 25 degrees west, 16 chains and 70 links; then north 9 degrees west, 18 chains and 60 links, to a white-oak tree, at the southwest corner of the land occupied in 1814 by Thomas Wilsey; then north 11 degrees east, 77 chains to the north side of a highway, where it is met by a fence dividing the possession of said Thomas Wilsey, jr., and Emery Hunt; then north 46 degrees east, 6 chains; then south 66 degrees east, 26 chains and 25 links; then north 9 degrees east, 27 chains and 50 links to a blue-slate stone, anciently set up for the southwest corner of Bennington; then north 7 degrees and 30 minutes east, 46 miles 43 chains and 50 links to a bunch of hornbeam saplings on the south bank of Poultney River, the northernmost of which was marked by said last-mentioned commissioners, and from which a large butternut tree bears north 70 degrees west, 30 links, a large hard maple tree, south 2 chains and 86 links, and a white ash tree on the north side of said river, north 77 degrees east.

Which said several lines from the monument erected for the southwest corner of the State of Vermont were established by said last-mentioned commissioners, and were run by them, as the magnetic needle pointed, in the year 1814, then down the said Poultney River, through the deepest channel thereof to East Bay; then through the middle of the deepest channel of East Bay and the waters thereof to where the same communicate with Lake Champlain; then through the deepest channel of Lake Champlain to the eastward of the islands called the Four Brothers, and the westward of the islands called the Grand Isle and Long Isle, or the Two Heroes, and to the west-



BOUNDARY BETWEEN VERMONT AND NEW YORK.



BOUNDARY BETWEEN VERMONT AND NEW YORK.

ward of the Isle La Motte to the line in the 45th degree of north latitude, established by treaty for the boundary line between the United States and the British Dominions. (See Revised Statutes of New York, Banks & Brothers, sixth edition, Vol. I, pp. 122-123.)

This line was changed in 1876 by a cession of a small territory from Vermont to New York, described as follows, viz:

All that portion of the town of Fairhaven, in the county of Rutland, and State of Vermont, lying westerly from the middle of the deepest channel of Poultney River as it now runs, and between the middle of the deepest channel of said river and the west line of the State of Vermont as at present established. (Ratified by Congress April 7, 1880.)

MASSACHUSETTS.

The territory of Massachusetts was included in the first charter of Virginia, granted in 1606, (*Vide* Virginia p., 94) and in the charter of New England, granted in 1620, (*Vide* Maine p. 39.)

In 1628 the council of Plymouth made a grant to the governor and company of Massachusetts Bay in New England, which was confirmed by the King, and a charter was granted in 1629, of which the following are extracts:

* * * Nowe Knowe Yee, that Wee * * * have given and granted * * * all that Parte of Newe England in Amirica which lyes and extends betweene a great River there commonlie called Monomack River, alias Merrimack River, and a certen other River there, called Charles River, being in the Bottome of a certen Bay there, comonlie called Massachusetts alias Mattachusetts, alias Massatusetts Bay, and also all and singuler those Landes and Hereditament whatsoever, lying within the Space of Three Englishe Myles on the South Parte of the said River called Charles River, or of any or every Parte thereof. And also all and singuler the Landes and Hereditaments whatsoever, lying and being with the space of Three Englishe Miles to the southward of the southermost Parte of the said Baye, called Massachusetts, alias Mattachusetts, alias Massatusetts Bay—and also all those Lands and Hereditaments whatsoever, which lye and be within the spaco of Three English Myles to the Northward of the saide River, called Monomack, alias Merrymack, or to the Norward of any and every Parte thereof and all Landes and Hereditaments whatsoever, lyeing within the Lymitts aforesaide, North and South, in Latitude and Bredth, and in Length and Longitude, of and within all the Bredth aforesaide, throughout the Mayne Landes there from the Atlantick and Westerne Sea and Ocean on the East Parte, to the South Sea on the West Parte.

* * * Provided alwayes, That yf the said Landes * * * were at the tyme of the graunting of the saide former Letters patents, dated the Third Day of November, in the Eighteenth yeare of our said deare Fathers Raigne aforesaide, actuallie possessed or inhabited by any other Christian Prince of State, or were within the Boundes Lymitts or Territories of that Southern Colony, then before graunted by our saide late Father * * * That then this present Graunt shall not extend to any such partes or parcells thereof * * * but as to those partes or parcells * * * shal be vtterlie voyd, theis presents or any Thinge therein conteyned to the contrario notwistanding * * *

The charter of New England was surrendered to the King in 1635. (*Vide* Plymouth Colony Laws, p. 333.)

The charter of 1629 was canceled by a judgment of the high court of chancery of England, June 18, 1684. (*Vide* C. & C., p. 942.)

In the year 1686, Pemaquid and its dependencies were annexed to the New England government. (*Vide* Maine, p. 40.)

In 1691 a new charter was granted to Massachusetts Bay, which included Plymouth Colony and the Provinces of Maine and Nova Scotia. The following are extracts from this charter:

> * * * Wee * * * do will and ordeyne that the Territories and Collonyes Commonly called or Known by the names of the Collony of the Massachusetts Bay and Collony of New Plymouth the Province of Main the Territorie called Accadia or Nova Scotia and all that tract of Land lying betweene the said Territories of Nova Scotia and the said Province of Main be erected Vnited and Incorporated * * * into one reall Province by the Name of Our Province of the Massachusetts Bay in New England. * * *
>
> All that parte of New England in America lying and extending from the greate River com̄only called Monomack als Merrimack on the Northpart and from three Miles Northward of the said River to the Atlantick or Western Sea or Ocean on the South part And all the Lands and Hereditaments whatsoever lying within the limitts aforesaid and extending as farr as the Outermost Points or Promontories of Land called Cape Cod and Cape Mallabar North and South and in Latitude Breadth and in Length and Longitude of and within all the Breadth and Compass aforesaid throughout the Main Land there from the said Atlantick or Western Sea and Ocean on the East parte towards the South Sea or Westward as far as Our Collonyes of Rhode Island Connecticutt and the Narragansett Countrey all alsoe all that part or porc̄on of Main Land beginning at the Entrance of Pescataway Harbour and soe to pass vpp the same into the River Newickewannock and through the same into the furthest head thereof and from thence Northwestward till One Hundred and Twenty miles be furnished and from Piscataway Harbour mouth aforesaid North-Eastward along the Sea Coast to Sagadehock and from the Period of One Hundred and Twenty Miles aforesaid to crosse over Land to the One Hundred and Twenty Miles before reckoned up into the Land from Piscataway Harbour through Newickawannock River and alsoe the North halfe of the Isles and Shoales togather with the Isles of Cappawock and Nantukett near Cape Cod aforesaid and alsoe [all] Lands and Hereditaments lying and being in the Countrey and Territory com̄only called Accadia or Nova Scotia And all those Lands and Hereditaments lying and extending betweene the said Countrey or Territory of Nova Scotia and the said River of Sagadahock or any part thereof And all Lands Grounds Places Soiles Woods and Wood grounds Havens Ports Rivers Waters and other Hereditaments and premisses whatsoever, lying within the said bounds and limitts aforesaid and every part and parcell thereof and alsoe all Islands and Isletts lying within tenn Leagues directly opposite to the Main Land within the said bounds. * * *

(For an account of the settlement of the boundary between the District of Maine, formerly a part of Massachusetts, see Maine, p. 41.)

The present northern boundary of Massachusetts was settled in 1741. (For history, see New Hampshire, p. 48.)

The boundary line between Massachusetts and Rhode Island was for more than two hundred years a question of dispute, and was, in some respects, the most remarkable boundary case with which this country has had to do. Twice the case went to the Supreme Court of the United States, and in one of these suits Daniel Webster and Rufus Choate were employed as counsel for Massachusetts.

As early as 1642 the line between the two colonies was marked in part by Nathaniel Woodward and Solomon Saffrey, who set up on the plain of Wrentham a stake as the commencement of the line between Massachusetts Bay and Rhode Island. This stake was by them supposed to mark a point 3 miles south of the Charles River.

The report of these commissioners has not been found, but frequent reference is made to their survey in the record of the subsequent controversies and litigations.

In 1710–'11 commissioners appointed from Massachusetts and Rhode Island agreed upon the north line of Rhode Island. The action of the commissioners was approved by the legislatures of both colonies.

The agreement was as follows, viz:

That the stake set up by Nathaniel Woodward and Solomon Saffrey, skillful, approved artists, in the year of our Lord 1642, and since that often renewed in the latitude of 41° 55′, being 3 English miles distant southward from the southernmost part of the river called Charles River, agreeable to the letters patent for the Massachusetts Province, be accounted and allowed on both sides the commencement of the line between the Massachusetts and the colony of Rhode Island, from which said stake the dividing line shall run, so as it may (at Connecticut River) be 2¼ miles to the southward of a due west line, allowing the variation of the compass to be 9°; which said line shall forever, &c. (*Vide* Howard's Reports, S. C., Vol. 4, p. 631, *et seq.*)

In 1719 this line was run by commissioners appointed for the purpose. Subsequent investigation has shown that this line was run in a very irregular manner. (*Vide* R. I. Acts, May, 1867, page 6, *et seq.*)

The line between Massachusetts and the eastern part of Rhode Island was fixed by commissioners in 1741, from the decision of whom the colony of Rhode Island appealed to the King, who, in the year 1746, affirmed their decision by a royal decree.

The following is a record of the proceedings in council, together with the royal decree.

[Council Office. Council Register. Geo. II, No. 8, p. 204.]

AT THE COURT AT KENSINGTON
the 29th day of July 1742.

Present. The Kings Most Excellent Majesty, Archbp^{d} of Canturbury, Earl of Pembroke, Lord President Earl of Winchelsea, Lord Privy Seal Earl of Grantham, Duke of Bolton, Earl of Cholmondelly, Duke of Rutland, Earl of Wilmington, Marq^{s} of Tweedale, Earl of Bath, Visco^{t} Lonsdale, Mr. Chancellor of the Exche^{cr}, Lord Delaware, Sr Charles Wager, Lord Bathurst, Sr. William Younge, Lord Monsore, Sr John Norris, Mr Speaker Thomas Winnington Esq., Mr. Vice Chamberlin, George Wade Esq.

Upon reading this day at the board the humble Petetion and appeale of the Governor and company of the English of Rhode Island and Providence Plantations in New England in America from several particular parts of the determination of the commissioners appointed by his Majesty to settle the Boundary's of the said colony Eastwards with the Province of Massachusetts Bay, and humbly praying that a day may be appointed for hearing said appeal, and that the particular parts of the said commissioners determination appealed from may be reversed, and such other determination made instead thereof as shall be agreeable to the true construction of the Boundarys contained in the Royal Charter under which the Petioners claim, It is ordered by his Majesty in Council that the said Petition and appeal (a copy whereof is hereunto annexed). Be and it is hereby referred to the Right Honorable the Lord of the committee of council for hearing appeals from the Plantations to hear the same, and report their opinion thereupon to his Majesty at the Board.

A true copy.

I. B. LENNARD.

Collated with the original entry in the Council Register, 18 Jan'y, 1845.

ROBT. LEMON.

[Council Office. Council Register. Geo. II, No. 8 p. 286.]

AT THE COURT OF KENSINGTON,
the 15th day of Sept. 1742.

Present, The Kings most Excellent Majesty Archbp of Canturbury, Lord Delmar Lord Chancellor, Mr Vice Chamberlin, Duke of Richmond, Mr. Chancellor of the Exchequer, Duke of Newcastle, Harry Pelham Esq. Earl of Winchelsea, Thomas Winnington Esq Earl of Wilmington George Wade Esq. Lord Cartaret.

Upon reading this day at the Board the humble Petition and appeale of His Majesty's Province of the Massachusetts Bay in New England from the determination of the commissioners appointed by His Majesty to settle the Boundary of the Colony of Rhode Island Eastwards, with the said province of Massachusetts Bay and humbly praying that a day may be appointed for hearing the said appeale and that the determination of the said commissioners may be reversed, and such other determination made instead thereof as shall be agreeable to the petioners claim exhibited before the said commissioners—It is ordered by his Majesty in council that the said petition and appeale (a copy whereof is hereunto annexed) Be and it is hereby referred to the Right Honorable the Lords of the committee in council for hearing appeals from the Plantations to hear the same and report their opinion thereupon to His Majesty at the Board.

A true copy.

I. B. LENNARD.

Collated with the original entry in the Council Registry, 18 of Jan'y, 1845.

ROBT. LEMON.

[Ordered in Council, dated 28th May, 1746. Council office. Council Register. Geo. II, No. 10, p. 4[illegible].]

AT THE COURT OF KENSINGTON,
the 28th day of May 1746.

Present the Kings Most Excellent Majesty in Council

Upon reading at the Board a Report from the Right Honourable the Lord of the committee of council for hearing appeals from the Plantations dated the 11th of December 1744 in the words following vizt.

Your Majesty having been pleased by Your Order in council of the 29th of July 1742 to refer unto this committee the humble petition and appeale of the Governor and company of the English Colony of Rhode Island and Providence Plantations in New England in America, from several particular parts of the determination of the commissioners appointed by your Majesty to settle the Boundarys of said colony eastwards with the Province of Massachusetts Bay and humbly praying that the particular parts of the said commissioners determination appealed from may be reversed, and such other determinations made instead thereof, as shall be agreeable to the true construction of the Boundarys continued in the Royal Charter under which the petitions claim—and your Majesty having been also pleased by another order in council of the 15th of September 1742, to refer unto this committee, the humble Petition and appeal of your Majesty's Province of the Massachusetts Bay in New England parte of the said determination of the said commissioners, and humbly praying that the same may be reversed and set aside and that instead thereof Your Majesty will be graciously pleased to give such judgement and determinations as shall be agreeable to the petitioners claim exhibited before the said commissioners. The Lords of the committee in obedience to your Majesty's said orders of Reference, have met several times, and taken both the said Petitions of Appeale into their consideration, and having examined into the Proceedings of the said commissioners, do find that they pronounced their judgements or determination on the 30th of June 1741 in the words following:

The court took into consideration, the charters, Deeds and other Evidences, Claims Pleas and allegations produced and made by party refering to the controversy before them and after mature advisement, came to the following Resolutions: That there is not any one Evidence proving that the Water between the Main Land on the East, and Rhode Island on the West, was ever at any time called Naragansett River, that though there be evidence that the place where the Indian called King Philip lived near Bristol, was called Pawconoket, and that another place near Swansey was called Sowams or Sowamsett, yet no evidence has been produced of the extent of the Pawconoket country to Seaconk, or Pawtucket River, as it runs to the line of the late Colony of the Massachusetts Bay, for tho' there be some evidence that the Indians at enmity with King Philip, or with other Indians in enmity with him, lived on the west side of the said River, and that the Indians subject to King Philip, or in amity with him, lived on the East side of the said River there is no Evidence that all the Indians subject to, or in amity with King Philip, lived in the Pawconoket Country. That the Province not having produced the Letters Patent, constituting the council of Plymouth, nor any copy thereof, the Recital of said Letters Patent in the deed from the council of Plymouth, to Bradford and his associates, is not sufficient evidence against the Kings Charter. That the council of Plymouth being a Corporation, could not create another corporation, and that no Jurisdiction within the Kings Dominions in America can be held by Prescription or on the Foot of Prescription. That the determination of the boundarys of the colony's of Rhode Island and New Plymouth by the Kings Commissioners in the year 1664 appear to have been only a temporary order for preserving the Peace on the Borders of both Colonys without determining the Rights and Titles of either. Upon the whole nothing appears whereby the Colony of Rhode Island and Providence plantations can be barred or hindered from extending their Jurisdiction Eastward towards the Province of the Massachusetts Bay according to the true intents and meaning of their charter. But some dispute having arisen between the Partys as to the true construction and meaning thereof, the court is of opinion, That the Narragansett Bay is and extendeth itself from Point Judith in the west to Seaconet Point on the East and including the Islands therein, layeth and extendeth itself unto the mouth of the River which runnith towards the town of Providence and that as it so lies or extends, it has and may be considered as having one Eastern Side at the Eastern coast of the said Bay runs up northerly from Seconets Point,—and one other North Eastern Side from near Mount Hope to Bullocks Neck, as the said Bay runs up North Westerly towards the Town of Providence and that the land adjacent to the said North Eastern and Eastern Coasts and including within the following lines and the said Bay are within the Jurisdiction of the Colony of Rhode Island; Vizt on the North East side of the said Bay—one line running from the south west corner of Bullocks Neck, Northeast three Miles. One other line running from the Northeast extremity of the said line until it be terminated by a line three miles Northeast from the northeasternmost part of the Bay on the west side of Rumstick Neck, and one other line from the termination of the west line to the Bay at or near Towoset Neck, running so that it touch the North East extremity of a line running three miles North East from the North East corner of Bristol Harbour, and on the Eastern side of the said Bay; One line from a certain point on the Eastern side of the said Bay opposite to the southernmost part of the Shawmuts Neck, and

four hundred and forty Rods to the Southwards of the Mouth of Fall River running East three miles; One other line running from the Easternmost extremity of the said line till it be terminated by the Easternmost end of a line three miles East from the Easternmost part of a cove in the said Bay which is to the southward of Nawquaket and one other line from the termination of the last line to the sea, running on such course, as to be three miles East from the Easternmost part of the Bay adjoining to Scitchuwest on Rhode Island, and that the said Distances of three miles East and Northeast, are to be measured from high Water Mark, and this court doth hereby settle, adjust and determine, that the Eastern Boundary of the said Colony of Rhode Island and Providence Plantations, towards the Massachusetts Bay, is, shall be and runs from a certain Pointe (where a Meridian line passing through Pawtuckets Falls, cuts the South Boundary of the Colony of Massachusetts Bay), south to Pawtuckets Falls, Then southerly along the eastward side of Seaconk River, and the River which runnith towards the Town of Providence, to the Southwest corner of Bullock's Neck, then Northeast three miles; and then along the aforesaid lines running at three miles distance from the Easternmost parts of the said Bay to the said Bay, at or near Towoset Neck. Then as the said Bay runs to the southernmost point of Shawmuts Neck, and then in a straight line to the aforesaid point opposite to the said Neck. Then East three miles and then along the aforesaid lines, running at three miles distance from the Easternmost parts of the said Bay, to the sea. All which lines are to be run by making the proper allowance for the variation of the Magnetic Needle from the Meridian. And for the better understanding of the description of the lines before mentioned; the Court hath caused the Boundary lines of the lands adjacent to the said most eastern and Northeastern points of the Said Bay, to be delineated on the Map or Plan of the said Bay and countries adjacent now in court, and the same are distinguished on the said Map or Plan, by A, B, C, D, E, F, G, H.

The Lord of the Committee having considered the whole matter and heard all partys concerned therein by their Council learned in the Law, Do agree humbly to report to your Majesty as their opinion, That the said Judgment or determination of the said Commissioners should be affirmed, and both the Petitions of Appeal therefrom dismissed.

His Majesty this day took the said Report into consideration and was pleased with the advice of the Privy Council to approve thereof, and to order, that the said Judgment or Determination of the said Commmissioners, Be, and it is hereby Affirmed And both the said Petitions of Appeal therefrom dismissed.

Whereof the Governor or the Commander in Chief of His Majesty's Province of the Massachusetts Bay, The Governor and Company of the colony of Rhode Island and Providence Plantations for the time being, and all others whom it may concern, are to take notice and govern themselves accordingly.

A true Copy.

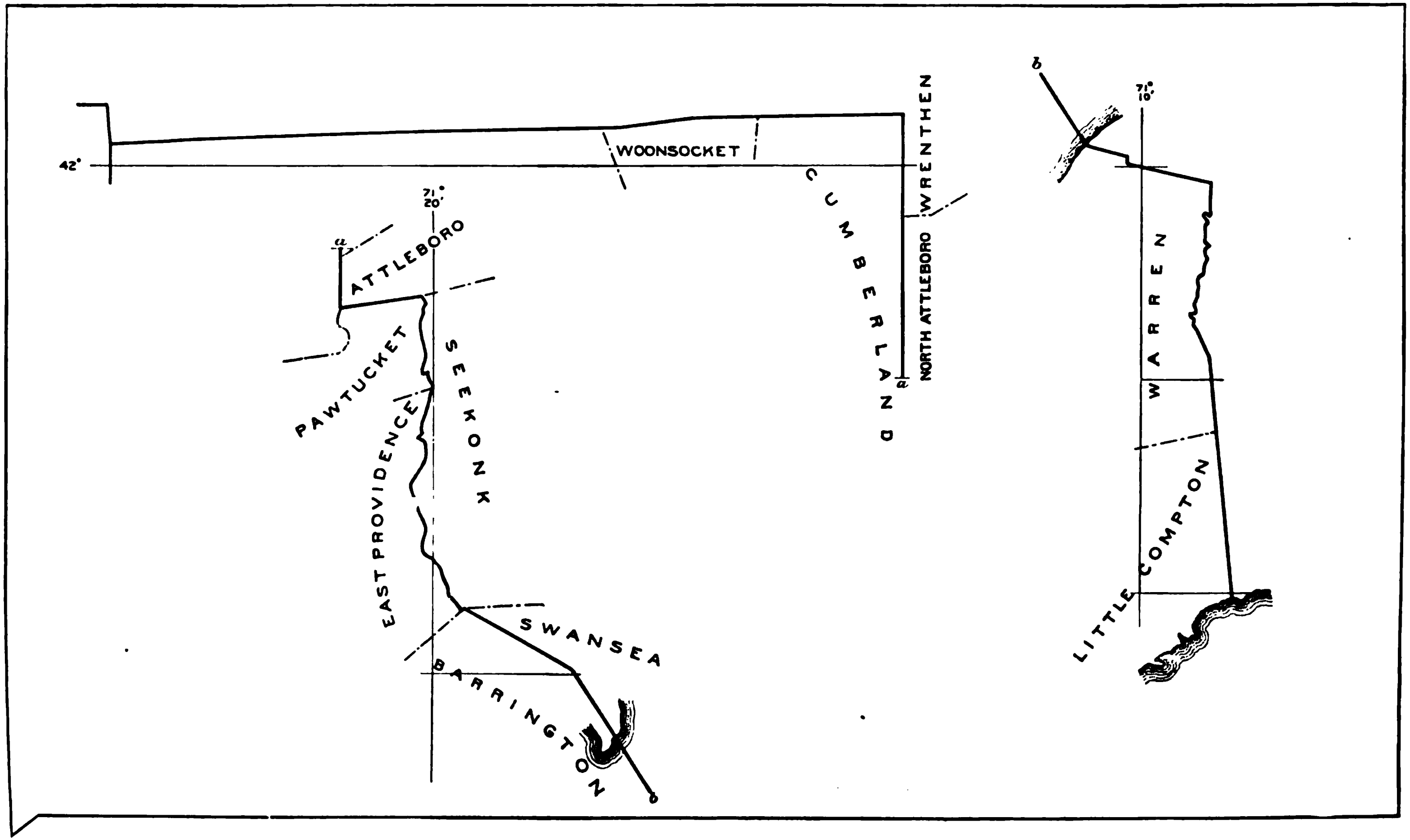
I B LENNARD.

Colated with the Original entry in the Council Register, 18 January, 1745.

ROBT LEMON.

Under the foregoing decree the line was run by commissioners appointed for the purpose, whose report was as follows, viz:

We, the subscribers, appointed commissioners by the general assembly of the colony aforesaid, to mark out the bounds of said colony eastward towards the province of Massachusetts Bay, agreeable to His Majesty's royal determination in council, the 28th day of May, 1746, did in pursuance thereof, on the second day of December last past, meet at Pawtucket Falls, in expectation of meeting with commissioners that might be appointed by the province of the Massachusetts Bay, for the purpose aforesaid; and after having there tarried till the afterpart of said day, and no commissioners in behalf of the said province appearing, we proceeded to run a due north line



BOUNDARY BETWEEN MASSACHUSETTS AND RHODE ISLAND.

from Pawtucket Falls to the south boundary of the aforesaid province of the Massachusetts Bay, in manner following, viz: From a certain point on the southern side of Pawtucket Falls, where we erected a monument of stones, with a stake thereon, we run a meridian line which directly passed through said falls, to a walnut tree on the northerly side of said falls; then to a pitch pine tree; then to a small white oak; then to a grey oak; then to a small bush; then to another small bush with stones about it; then to a heap of stones with a stake thereon; then to a black oak tree; then to another black oak; then to a small pitch pine; then to a black oak; then to a large white oak near the river, called Abbot's Run; then to a poplar tree; then to a heap of stones with a stake thereon; then to a large rock with stones thereon; then to a small black oak tree; then to a walnut tree; then to a black oak; then to divers other marked trees in the said course, to the extremity of said line; and when we came near the termination of the said line made a monument of stones, there being no noted south boundary of the said province near the said line, and therefore, for the discovery of the south boundary of the said province, upon the best information we could obtain, proceeded to Wrentham Plain, at or near to a place where was formerly erected a stake, called Woodward's and Saffery's stake, as one remarkable south boundary of the said province, and from thence run a west line, making an allowance of eight degrees and a half as the west variation of the magnetic needle from the true meridian, it being the course of the south line of the said province, according to their charter (as we apprehended), and then we extended the said north line from the aforesaid monument till it intersected the said west line, and upon the point of its intersection erected a monument of stones with a stake thereon, as the northeast boundary of that tract of land commonly called the Gore.

After which we proceeded to Bullock's Neck, and on the southeast corner thereof erected a red cedar post, marked with the letters J. H. C. R., with the figure of an anchor thereon, and from thence running a line northeast making the same allowance for the variation aforesaid, to a black oak tree marked with the letters G. C. C. R., then to a large white oak marked with the letters G. B. C. R., then to a white oak post, set in the ground with a heap of stones around it, marked with the letters G. W. C. R., with the figure of an anchor thereon, being three miles distant from Bullock's Neck aforesaid.

After which we proceeded to the northeasternmost part of the bay on the west side of Rumstick Neck, and from a point where a locust post was erected, run a line three miles northeast, with the same allowance for the variation and at the extremity of the said line erected a monument of stones, from which we run a line to the northeast extremity of that line drawn from the southwest corner of Bullock's Neck aforesaid, the course whereof being west thirty-eight degrees north, according to the magnetic needle, the distance of nine hundred and fifty-five rods, marking trees and making other boundaries in the course of said line. After which we proceeded to the northeast corner of Bristol Harbour, and from high-water mark, which was some rods distant northeast from the bridge leading to Swanzey Ferry, we ran a line three miles northeast, still making the same allowance for the variation, and at the extremity of which line we erected a monument of stones; then we ran a line from the northeast extremity of the line drawn from Rumstick aforesaid, the course whereof being south twenty-five degrees east, till it met with the termination of the line drawn from Bristol Harbour aforesaid, the distance whereof being nine hundred and twenty-seven rods; and from thence to a straight line to the bay at Towoset Neck, making proper boundaries in the course of said line.

After which we proceeded to the eastern side of the Narragansett Bay, and on the easternmost part of a cove in the said bay, which is southward of Nanequachet, ran a line three miles east (still making the same allowance for variation), at the extremity whereof we marked a grey oak tree with the letters C. R., with the figure of an anchor thereon.

After which we proceeded to the mouth of Fall River, and from thence measured four hundred and forty rods southerly on the shore, as the said shore extendeth itself from the mouth of said Fall River, and from the point where the said four hundred and forty rods reached, being east thirty-five degrees south of the southernmost point of Shawomet Neck, we ran a line three miles east, with the same allowance for the variation; in the course whereof we marked divers trees, and came to a large pond, on the west of which was a small oak between two large rocks, and from thence measured over the said pond to a bunch of maples, two whereof we marked with the letters I and F, standing on a place called Ralph's Neck, being the extremity of the said three miles; from thence we ran a line south twenty degrees west, two thousand one hundred and twenty-three rods (making proper boundaries in said line), till we met the termination of the three-mile line, ran from the cove southward of Nanequachet aforesaid.

After which we proceeded to a place called Church's Cove, in said bay, and ran a line three miles east, making the same allowance for the variation aforesaid, and at the extremity whereof, and near the sea, we erected a monument of stones, and from thence ran a line north two degrees and a quarter east, one thousand and nine hundred and forty-one rods, till it also met the termination of the said line, drawn from the first mentioned cove as aforesaid, making proper boundaries in the course of said line.

The aforegoing is a just account of our proceedings, and report the same accordingly.

J. HONEYMAN, JR.
GEORGE WANTON.
GIDEON CORNELL.
GEORGE BROWN.

And it is voted and resolved, That the said report be, and it is hereby, accepted by this assembly.

In the year 1748 the legislature of Rhode Island appointed commissioners to continue the line to the Connecticut corner, recognizing the Woodward and Saffrey stake as the place of beginning. Massachusetts failed to appoint commissioners, whereupon the Rhode Island commissioners proceeded to complete the running of the line. In their report they say—

That we not being able to find any stake or other monument which we could imagine set up by Woodward and Saffrey, but considering that the place thereof was described in the agreement mentioned in our commission, by certain invariable marks, we did proceed as followeth, namely: We found a place where Charles River formed a large current southerly, which place is known to many by the name of Pappatalish Pond. which we took to be the southernmost part of said river, from the southernmost part of which we measured three English miles south, which three English miles did terminate upon a plain in a township called Wrentham. (See Howard's Reports S. C., vol. 4, page 632).

From this point they ran the line. From this time forward repeated steps were taken by Rhode Island by resolutions, and by appointment of commissioners at different times to ascertain and run the line, in connection with commissioners from Massachusetts; commissioners from both colonies met more than once, but they failed to agree upon a boundary in place of that established under the agreements of 1711-'18. Rhode Island alleged a mistake in her commissioners, in the place of beginning (that is, on Wrentham Plain), as the ground of these efforts.

This controversy, however, embraced the entire line from the State of

Connecticut to the Atlantic Ocean. Massachusetts asserted that an encroachment had been made on her territory from Burnt Swamp Corner to the ocean by Rhode Island, who, on her part, claimed that the jurisdictional line of Massachusetts from said corner to the Connecticut line was, in its whole extent, upon the territory of Rhode Island. The legislatures of the respective States having failed, after repeated effort, to adjust the controversy, Rhode Island in 1832, by a bill in equity, brought the subject of the northern boundary, from Burnt Swamp Corner to the Connecticut line, before the Supreme Court of the United States, which in 1846 decided that the jurisdictional line claimed by Massachusetts was the legal boundary of the two States between these points.

While this suit was pending an attempt was made to settle the long controversy by an amicable adjustment of the whole line from Connecticut to the ocean. Commissioners were appointed by both States in 1844 to ascertain and mark the true boundary from Pawtucket Falls to Bullock Neck. In 1845 the same commissioners were authorized to ascertain the line from Burnt Swamp Corner to the Atlantic Ocean.

In 1846, the equity suit having been decided, they were authorized "to erect suitable monuments at the prominent angles of the line, from the Atlantic Ocean to the northwest corner of Rhode Island, and at such other points on the line as may subserve the public convenience." A majority of said commissioners agreed upon a line and erected monuments in 1847.

The report of the joint commission was dated Boston, January 13, 1848.

The line so agreed upon as a boundary between Burnt Swamp Corner and the northwest corner of Rhode Island was a straight line, varying a little from the irregular jurisdictional line established by the decision of the Supreme Court, and is described in the joint report of the majority of the commissioners of January, 1848, as follows, viz:

> Begin at the northwest corner of Rhode Island, on Connecticut line, in latitude 42° 00′ 29″ north, and longitude 71° 48′ 18″ west of Greenwich, thence easterly in a straight line 21.512 miles to Burnt Swamp Corner, in Wrentham, being in latitude 42° 01′ 08″ and longitude 71° 23′ 13″.

Upon this line were placed twenty-seven monuments, exclusive of that at Burnt Swamp Corner.

The general assembly of Rhode Island, in May, 1847, ratified and established the line from the ocean to the Connecticut line, "to take effect and become binding whenever the said agreement and boundary line should be ratified by the State of Massachusetts." The legislature of Massachusetts did not ratify the said agreement and boundary line, but proposed another joint commission, which was agreed to.

The attempt made by these commissioners to settle the line having failed, Massachusetts commenced a bill in equity before the Supreme Court of the United States for an adjudication of the boundary line from Burnt Swamp Corner to the Atlantic Ocean.

In 1860 both States agreed upon a conventional line, and asked that a decree of the United States Supreme Court should confirm the same, which prayer was granted, and the line was thus finally established by a decree rendered in the December term, 1861, which is as follows, viz:

Beginning at Burnt Swamp Corner (so called), in Wrentham, in latitude 42° 01′ 08″ north, longitude 71° 23′ 13″ west of Greenwich, being the northeasterly corner of Rhode Island.

Thence in a straight line to the center of a stone monument in the division line, between Attleborough and Pawtucket, on the easterly bank of the Blackstone River, being in latitude 41° 53′ 36″ north, longitude 71° 23′ 14″ west.

Thence easterly, by the northerly line of the town of Pawtucket, to a point where said line intersects the highest water mark on the easterly side of Farmer's or Seven Mile River, which point is shown on accompanying sheet marked "A," and designated as "Bound No. 1," being in latitude 41° 53′ 54″ north, longitude 71° 20′ 40″ west.

From Bound No. 1 the line runs southerly, following the highest water mark on the easterly side of Farmer's or Seven Mile River, as designated in said sheet marked "A," to its junction with the highest water mark on the southerly and easterly side of Ten Mile River, at a point designated as "Bound No. 3."

From Bound No. 3 the line runs southerly, following the highest water mark on the southerly and easterly side of said Ten Mile River, as shown on sheet marked "A," to a point designated as "Bound No. 13," said last point being at the most southerly bend of Ten Mile River in said line of highest water mark.

The line of "highest water mark" as shown on sheet A is defined by offsets at right angles to straight lines shown on said plan in blue ink, from Bound No. 1, and passing through points designated as bounds numbered 2 to 13, inclusive.

From Bound No. 13 the line runs southeasterly, being a straight line to the center of a stone pier in the middle of Runnin's River, on the north side of the road leading by Luther's store.

Thence through the center or middle of said Runnin's River as the same is at low water at a point when such line intersects the dividing line between Barrington and Seekonk, being in latitude 41° 46′ 28″, longitude 71° 19′ 23″.

Thence northeasterly, following the dividing line between Barrington and Seekonk, to a point at the northerly extremity of the dividing line between Barrington and Swanzey, in latitude 41° 36′ 34″, longitude 71° 19′ 30″.

Thence in a straight line southeasterly to the center of a copper bolt in King's Rock, so called and well known, near an ancient monument on said King's Rock, being on the west side of the road leading from Warren to Swanzey. This point is in latitude 41° 45′ 22″.98, longitude 71° 16′ 35″.75.

From King's Rock the line follows the dividing line between Warren and Swanzey to Mount Hope Bay, running in a straight line southeasterly to a point on the Birch Swamp Farm, in latitude 41° 45′ 08″, longitude 71° 15′ 58″.5.

Thence in a straight line to Mount Hope Bay, passing through the center of a copper bolt in a bowlder, in line of extreme high water at Toweset, to low-water line of said bay. This bolt is in latitude 41° 42′ 45″.27, longitude 71° 13′ 54″.70.

From Toweset the line runs southeasterly, crossing Mount Hope Bay, to the westerly end of line dividing Fall River and Tiverton, where the same intersects low-water line of said Mount Hope Bay.

Thence easterly, following said dividing line between Fall River and Tiverton, passing through the middle of a town way on the north side of farm belonging to John Chase, and through the southerly end of Cool's Pond, in a line passing through the middle of a highway, eight rods wide.

Thence running southerly through the center of said eight-rod highway to a point in line with the stone wall on northerly side of farm of Edmund Estes. This wall is easterly of the Stafford road (so called.)

Thence running easterly in line with said wall to a point in line of highest water mark on the westerly shore of South Watuppa Pond, which point is shown on accompanying sheet marked "B," and designated as "Bound A."

From Bound A the line runs southerly, following the highest water mark on westerly side of South Watuppa Pond, and of Sawdy Pond, and of the streams connecting said ponds, as shown on said sheet marked "B," to a point designated as "Bound F," said last point being at the most southerly end of Sawdy Pond in said line of highest water mark.

The line of "highest water mark" as shown on sheet B is defined by offsets at right angles to straight lines from Bound A, and passing respectively through points designated "B" to "F," inclusive, and on the South Watuppa Pond is also the line that would be traced by a level thirteen inches above a bolt in stone work on westerly side of waterway in gate-house of reservoir dam of Watuppa Reservoir Company, Quequechan River. On Sawdy Pond the highest water mark is the line that would be traced by the level of an iron bolt driven in west side of flume to saw-mill at northerly end of said Sawdy Pond.

From Bound F the line runs southeasterly, being a straight line to the monument known as "Joe Sanford's bound," being the center of a copper bolt in stone on land of Joseph Tripp, and is in latitude 41° 35′ 37″ longitude 71° 08′ 13″.

From Joe Sanford's bound the line runs southerly, following the westerly line of the town of Westport to the Atlantic Ocean, passing easterly of Quicksand Pond through the center of a bound known as Peaked Rock, situated in latitude 41° 29′ 58″, longitude 71° 07′ 34″.

The first point in this line southerly of Sanford's bound is on the north side of mill-dam at Adamsville, 85.58 feet easterly of straight line from Sanford's to Peaked Rock.

The second is 113.94 feet easterly of said straight line, and is on the easterly side of road leading from Adamsville to the ocean.

The third is 234.48 feet east of said straight line, on the road leading to Little Compton, by Philip Simmons' house.

The whole of the line thus described is shown on a plan herewith presented, which, with Sketches A and B, is made a part of this report and attested.

It will be observed that the above decree of the United States Supreme Court makes no reference to the line from Burnt Swamp Corner to the Connecticut line.

It will also be remembered (*vide* p. 61) that the "line of 1848," so called, was ratified by Rhode Island and rejected by Massachusetts. In 1865 the legislature of Massachusetts took action in regard to this portion of the line, as follows, viz:

Resolved, That the boundary line between the State of Rhode Island and the Commonwealth of Massachusetts, from the line of the State of Connecticut to Burnt Swamp Corner, begins at the northwest corner of the State of Rhode Island on the Connecticut line, in latitude 42° 00′ 29″ north, and longitude 74° 48′ 18″ west of Greenwich,[3] and runs in a straight line 21 add $\frac{418}{1000}$ miles to Burnt Swamp Corner, in Wrentham, being in latitude 42° 1′ 8″ and longitude 71° 23′ 13″.

This is the line agreed upon by the commissioners, called the "line of 1848," ratified at the time by Rhode Island, but rejected by Massachusetts.

The tardy ratification of the line by Massachusetts was, in its turn,

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[3] This is a clerical error. "Longitude 74° 48′ 18″" should read "longitude 71° 48 18″." (*Vide* Borden's Tables, p. 64).

rejected by Rhode Island, on the ground that the then recent settlement of the eastern boundary by the decree of the Supreme Court had so changed the aspect of the controversy that she could not consent to the adoption of the line of 1848 as her northern boundary.

Thus the northern boundary of Rhode Island was left in abeyance, or rather left in the condition prescribed by the decision of 1846.

In June, 1880, the legislature of Rhode Island passed a resolution to remove the monuments of the "line of 1848" and erect monuments on the jurisdictional line.

In 1881 the legislature of Massachusetts took like action.

This jurisdictional line has the same termini as the line of 1848, but is a very irregular line, sometimes running north of a direct line and sometimes falling south of it [the extreme variations being 529.3 feet north of the line of 1848, and 129 feet south of the same.] A full and detailed description may be found in Rhode Island acts, May, 1867, p. 6 *et seq.*

Also, *vide* Senate Document No. 14, Massachusetts, 1848, for a full account of this controversy.

In 1713, commissioners from the Province of Massachusetts Bay and Colony of Connecticut settled a line between Massachusetts and Connecticut.

By this line certain northern frontier towns were given to Massachusetts, viz: Woodstock, Suffield, Enfield, and Somers. In 1749 the legislature of Connecticut passed a resolution that, inasmuch as the line had not been approved by the King, and that the two colonies had no legal right to transfer territory without the confirmation of the Crown, the contract was void, and these towns were again taken under the jurisdiction of Connecticut. Massachusetts appealed to the King, and the claims of Connecticut were fully established. (See Hollister's History of Connecticut, Vol. II.)

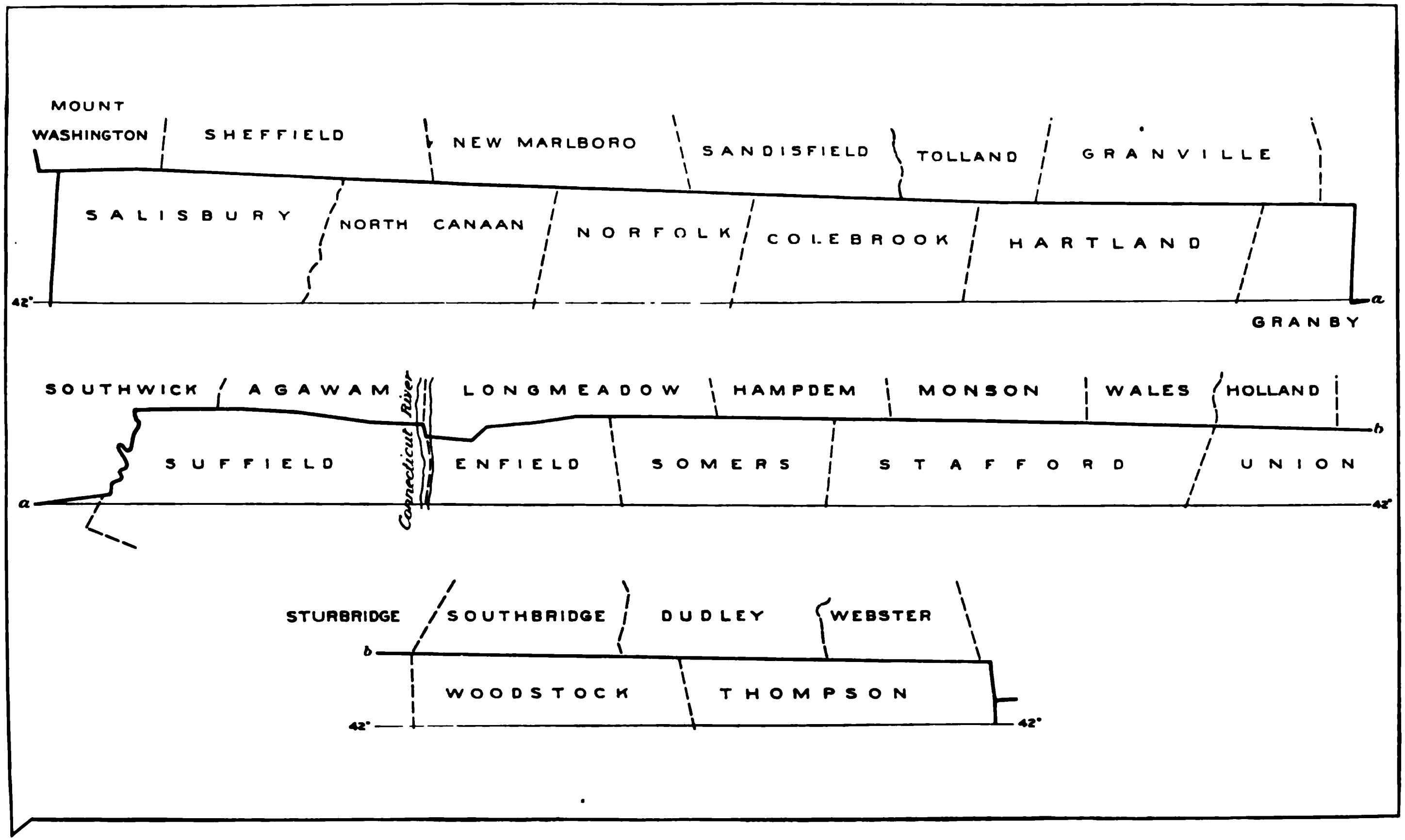
In 1791 Massachusetts and Connecticut appointed commissioners to establish the boundary between them, but they were unable to agree.

In 1803 commissioners were appointed to complete the line, a compromise having been made concerning the line between the town of Southwick and the towns of Suffield and Granby (the cause of the disagreement of the former commissioners).

The agreement made was as follows, viz:

> That the line should begin from a station 8 rods south of the southwest corner of West Springfield, and thence run west to the large ponds, and thence southerly by those ponds to the ancient south line of Westfield, and from thence on said south line to the ancient southwest corner of Westfield; and from thence northerly in the ancient west line of Westfield to the station in said west line made by commissioners in the year 1714, and from thence to the southwest corner of Granville. (See Mass Special Laws, Vol. III, page 234.)

In 1803 the commissioners surveyed and marked the boundary between their respective States.



BOUNDARY BETWEEN MASSACHUSETTS AND CONNECTICUT

Their report, which was adopted, is as follows, viz:

Beginning at the northeast corner of Suffield and the southeast corner of West Springfield, on the west bank of Connecticut River, at a point 75 links northward of the center of a small valley running into said river, said point being between a small butternut tree, marked M. C., standing on the south, and a small crooked white oak, marked M., standing on the north, about two feet distant from each other, and then run north 82° 45′ west 1 chain to a stone monument erected by us there; in the same course 22 chains 25 links to a stone monument on the stage road from Springfield to Suffield, and said course continued would pass two feet north of Smith's house; thence north 82° west 82 chains 3 links to a stone monument on the middle road from Suffield to Springfield; then in the same course 13 chains 30 links to a large black or red oak tree, marked on the east side C., and on the west side M., being an ancient bound; thence north 77° 4′ west 134 chains 42 links to a stone monument on the road from Feeding Hills meeting-house to Suffield; thence in the same course 4 chains 21 links to a pine stump—an old monument; thence north 79° 48′ west 102 chains 80 links to a stone monument on the road from Westfield to Suffield, called the back street; thence north 81° 30′ west 61 chains 20 links to a stone monument at an old stump and stones, the ancient southwest corner of West Springfield; thence south 5° west 2 chains to a stone monument in the line run by commissioners in 1714; thence north 85° west 167 chains 33 links to a stone monument at the middle pond, 22 links east of low-water mark, being at the center of a little valley running into said pond; thence on the eastern shore of said pond, as the same runs southerly, to a sluice way or outlet from said pond to the south pond; thence southerly on the east shore of the south pond as the same runs to a stone monument at high-water mark on the south corner of said pond, being the south end of the most southerly bay thereof, from which the point of land beyond the bay on the east side of the pond bears north 29° east, and the high point beyond the bay on the west side of the pond is north 3° 30′ east; then south 10° 20′ west 24 chains 78 links to a stone monument at the southeast corner of Southwick, in the ancient south line of Westfield, from which the highest peak of Manatick Mountain bears south 42° 30′ west; thence south 87° 30′ west 33 chains 86 links to a heap of stones in a hedge, being an ancient monument in the south line of Westfield and the northwest corner of Suffield, adjoining Granby; thence in said ancient south line of Westfield the same course to a stone monument at a white oak stump, an old monument, the southwest corner of Southwick, being 174 chains 36 links; thence north 10° 20′ east 212 chains 84 links to a stone monument erected by us, at a place in the ancient west line of Westfield, where commissioners in 1714 established the monument called the Crank monument; thence north 82° 17′ west 137 chains to a stone monument erected by us at the east road from Granby to Granville; in this course, at the distance of 86 chains 20 links from the Crank monument, we passed between two pillars of stones 45 links south of one and 13 links north of the other, both said to be the southeast corner of Granville; thence on the same course 61 chains 40 links to a stone monument erected by us on the Granby turnpike road; thence in the same course 44 chains to a white-oak[4] tree, marked by commissioners in 1717, and which we marked M on the north side and C, 1803, on the south side; thence north 84° 24′ west 5 chains 13 links to a stone monument erected by us on the west road from Granby to Granville; thence in the same course 200 chains 37 links to a white elm stump and stones on the west bank of Valley Brook, so-called, a monument, made by commissioners in 1717 in this course three monuments are mentioned by said commissioners, which we do not find; thence north 85° 7′ west 60 chains 15 links to a stone monument erected by us at a new road near the east bank of Hubbard River; thence the same course 2 chains to dry hemlock tree with stones about it on the west side of said river near a small fall and a rock on the east side of said river stooping towards it more than 2

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[4] Oak-tree boundary at Granville, marked in 1717.

rods to a monument erected by said former commissioners; thence north 82° 52′ west 109 chains 35 links to a stone monument[5] erected by us on the road from Granville to Hartland; thence the same course 275 chains 91 links to a large heap of stones on the west bank of Slocum Brook between two hemlock trees, having many ancient and modern marks thereon, being a monument made by said former commissioners; in this course, the commissioners of 1717 made mention of a large hemlock tree, and a very large white-ash tree which we do not find; thence north 81° 50′ west 93 chains 74 links to a stone monument erected by us on the Beach-hill Road, so-called; thence in the same course 235 chains to a stone monument erected by us at a heap of stones about an elm tree standing on the west bank of Sandy Brook, a monument made by said former commissioners, who mentioned in their report a monument in this course, which we do not find; thence north 82° 11′ west 357 chains 30 links to a stone monument erected by us on the road from Marlborough to Norfolk; thence same course 38 chains 20 links to a monument made by said former commissioners on the west bank of Whiting River, near falls, being a heap of flat stones on a large rock; thence north 82° 9′ west 219 chains to a stone monument at the end of Greenwood Turnpike road; in this course said former commissioners marked two trees, which we do not find: thence in the same course 161 chains 75 links to a stone monument at the Burrell Road, so-called, leading from Canaan to Suffield; thence in the same course 49 chains to an elm tree, with stones near it, on the east bank of Housatonic River, about six rods west from a chestnut stump and stones, a monument made by said former commissioners, who also marked a white oak tree in this course which we not find; thence north 82° 52′ west 20 chains 50 links to a stone monument erected by us at the road leading from Salisbury to Sheffield, called Wetany Road; thence in the same course 119 chains 50 links to a stone monument erected by us at the road from Salisbury to Sheffield, near Ebenezer Fletcher's house; thence on the same course 211 chains 35 links to a stone monument erected by us at the mountain road from Salisbury to Sheffield; thence on the same course 28 chains 4 links to a monument established by said former commissioners at the foot of the mountain, being a heap of stones on a large rock, 20 links long on the northeasterly side, 5 feet high on the southerly side, and which we marked 1803 on the southerly side; thence north 85° 30′ west 147 chains 20 links to a stone monument erected by us on the road from Salisbury to Mount Washington; thence on the same course 81 chains 80 links to a large heap of stones, the oblong corner bounds, so-called between the State of Connecticut and New York.

* * * * * * *

The courses of said line as before given, and here by us are according to the present state of Magnetic needle, which we observed to vary 5° west of north. (See Private Laws of Conn., vol. 2, pages 1540 to 1544.)

ABSTRACT OF REPORT OF COMMISSION OF 1803 ON BOUNDARY BETWEEN MASSACHUSETTS AND CONNECTICUT WEST OF THE CONNECTICUT RIVER.

Beginning at a point on the west bank of Connecticut River, in latitude 42° 01′ 52″.10, longitude 72° 37′ 03″.46, and running north 82° 45′ west 22 chains 25 links; thence north 82° west 95 chains 33 links; thence north 77° 4′ west 138 chains 63 links; thence north 79° 48′ west 102 chains 80 links; thence north 81° 30′ west 61 chains 20 links; thence south 5° west 2 chains; thence north 85° west 167 chains 33 links to a stone monument at the middle pond, 22 links east of low-water mark, latitude 42° 02′ 11″, longitude 72° 45′ 45″.07; thence southerly along the east shore of said pond, and also south pond, to a stone monument at high-water mark, at the south corner of said south pond; thence south 10° 20′ west 24 chains 78 links to a stone monument at southeast corner of Southwick, which is in latitude 42° 00′ 11″.98, lon-

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[5] Boundary stone in west front of Granville.

gitude 72° 46′ 24″.23; thence south 87° 30′ west 208 chains 22 links to a stone monument at the southwest corner of Southwick, which is in latitude 41° 59′ 51″.89, longitude 72° 49′ 25″.47; thence north 10° 20′ east 212 chains 84 links, to a stone monument at the northwest corner of the Southwick Jog, which is in latitude 42° 02′ 12″.39, longitude 72° 49′ 13″.51; thence north 82° 17′ west 242 chains 40 links to a white oak tree, marked by commissioners in 1717, which is in latitude 42° 02′ 15″.84, longitude 72° 52′ 47″.74; thence north 84° 24′ west 205 chains 50 links; thence north 85° 7′ west 62 chains 15 links; thence north 82° 52′ west 109 chains 35 links to a stone monument in latitude 42° 02′ 17″.03, longitude 72° 58′ 22″.52; thence north 82° 52′ west 275 chains 91 links; thence north 81° 45′ west 70 chains; thence north 81° 50′ west 328 chains 74 links to a stone monument, which is in latitude 42° 02′ 31″.11, longitude 73° 07′ 35″.94; thence north 82° 11′ west 395 chains 50 links; thence north 82° 9′ west 430 chains; thence north 82° 52′ west 140 chains to a stone monument on the road from Salisbury to Sheffield, which is in latitude 42° 02′ 58″.11, longitude 73° 22′ 55″.27; thence north 82° 52′ west 239 chains 39 links; thence north 85° 30′ west 239 chains to the northwest corner of Connecticut, which is in latitude 42° 02′ 58″.54, longitude 73° 30′ 06″.66.

According to the survey of the cession of Boston Corners, by Massachusetts to New York, in 1855, the south boundary of Massachusetts from the northwest corner of Connecticut to the southwest corner of Massachusetts is as follows, viz:

A line running north 89° 08′ 4″ west, 40 chains, by the true meridian.

The courses of the line of 1803 are magnetic, with the variation as at that date: *i. e.*, 5° west.

The latitudes and longitudes in the foregoing are taken from the Borden Trigonometrical Survey of Massachusetts of 1843.

In 1826, the line between Massachusetts and Connecticut east of the Connecticut River was run by commissioners appointed from each State. An abstract of the commissioners' report is here given:

Abstract of report of commissioners of 1826.—The commissioners first made the following survey: Commencing at the northeast corner of Connecticut, at a large pile of stones erected by commissioners of 1734; thence running due west on the latitude of 42° 3′ north to the west line of Woodstock, 15 miles 169 rods 15 links. (This is hereafter referred to as the "first line of latitude.") Thence north 3° west 54 rods 19 links to an old pine tree, the reputed northeast corner of Union; thence due west 25 miles 168 rods to Connecticut River. (This line is hereinafter referred to as the "second line of latitude," and the second line of latitude is 54 rods north of the first.) These lines of latitude were compared with the ancient survey, monuments, evidence, etc., of the line run by the commissioners of 1713; the said lines of latitude were found to vary in sundry places therefrom. Therefore, in order to conform as near as possible to the line of 1713, the line was run as follows, viz:

Beginning at the northeast corner of Connecticut and running west on "first line of latitude" 1,702 rods and 4 links to the road to the Merino road; thence in a direct line 1,372 rods 20 links to the road leading from Muddy Brook, so called, by Pennel May's to Southbridge; this point is 21 rods 10 links north of the "first line of latitude"; thence in a direct line 360 rods 5 links to the Norwich and Woodstock turnpike (tl is point is 20 rods and 5 links north of "first line of latitude"); thence in a direct line 954 rods 18 links to the road leading from West Woodstock by Abel Mason's to Southbridge (this point is 10 rods and 22 links north of "first line of latitude"); thence in a direct line 1,247 rods to the road leading from Union by Asher Bodgen's to Holland (this point is 2 rods 14¾ links south of "second line of latitude"); thence in a direct line 1,127 rods to the turnpike from Hertford through Stafford and Holland to Worcester (this point is 6 rods 23¼ links south of the "second line of latitude"); thence in a direct line 467 rods to an old white-oak tree, an ancient bound, on the road from Stafford by Robert Andruss' to South Brimfield (this point is 1 rod 2 links south of "second line of latitude"); thence in a direct line of 1,615 rods to the road leading from Stafford by Henry Cady's to Monson (this point is 16 rods 15 links south of "second line of latitude)"; thence in a direct line 256 rods to the Tracy road (this point is 12 rods 12 links south of "second line of latitude)"; thence in a direct line 620 rods to the road leading from Stafford by Seth Sheldon's to South Wilbraham (this point is 14 rods 7 links south of "second line of latitude"); thence in a direct line 1,066 rods to the road from Somer's by Walter Ainsworth's to Springfield (this point is 4 rods 1 link *north* of "second line of latitude"); thence in a direct line 523 rods to the road from Somer's by Abel Peas's to Springfield (this point is 6 rods 12 links south of the "second line of latitude"); thence *due west* 645 rods to the ancient line between Springfield (now Long Meadow) and Enfield; thence *south* 80° 30′ *west* by the true meridian 645 rods to a monument at an old oak stump; thence *south* 51° 30′ *west* by the true meridian 164 rods 18 links to a monument at an old pine stump; thence *due west* 349 rods 15 links to a monument on the Connecticut River 12 rods from the shore; thence due west to Connecticut River. On the line are erected 49 monument stones, marked on the north side M and on the south side C.

The commissioners also surveyed and marked the line from the the corner of Connecticut to the corner of Rhode Island, reporting as follows:

> Beginning at the monument erected at the northeast corner of said State of Connecticut and running in a direct line to the ancient heap of stones on the north side of the turnpike leading from Hertford to Boston through Thompson and Douglass, where we erected a monument, and thence running in a direct line to the northwest corner of the State of Rhode Island.

(For survey of 1826, see Private Laws of Conn., vol. 2, pages 1544 to 1550.)

The boundary between Massachusetts and New York at an early period became a subject of bitter dispute, New York claiming to the west bank of the Connecticut River under the charters of 1664 and 1674 to the Duke of York, Massachusetts claiming under her old charters to the South Sea. After many fruitless attempts at a settlement, an arrangement was entered into in 1773 fixing the western boundary of Massachusetts where it meets New York territory. The Revolution following soon after, the line was not run. In 1785 Congress appointed three commissioners to run the line, who performed that duty in 1787. The line was as follows, viz:

> Beginning at a monument erected in 1731 by commissioners from Connecticut and New York, distant from the Hudson River 20 miles, and running north 15° 12′ 9″, east 50 miles 41 chains and 79 links, to a red or black oak tree marked by said commissioners, which said line was run as the magnetic needle pointed in 1787. (*Vide* Revised Statutes of New York, 1875, p. 122.)

The claims of Massachusetts to western lands were finally settled December 16, 1786, by a joint commission of the two States. By this agreement Massachusetts surrendered the sovereignty of the whole disputed territory to New York, and received in return the right of soil and pre-emption right of Indian purchase west of the meridian passing through the eighty-second mile-stone of the Pennsylvania line, excepting certain reservations upon Niagara River. The title to a tract known as "The Boston Ten Towns," lying east of this meridian, previously granted by Massachusetts, was also confirmed. (*Vide* Hough's N. Y. Gaz., 1872, pp. 25, 26.)

April 19, 1785, Massachusetts executed a deed to the United States. It included all title of the State of Massachusetts to territory west of the present western boundary of New York.

In 1820 Maine, hitherto a part of Massachusetts, was admitted into the Union as an independent State.

In 1853 a small portion of territory in the southwestern corner of Massachusetts, known as Boston Corner, was ceded to New York, and the cession confirmed by Congress in 1855.

The cession of Boston Corner to New York changes the boundary, so that it is now as follows, viz:

Beginning at a monument erected in 1731 by commissioners from Connecticut and New York (known as the Connecticut monument), standing in the south boundary of Massachusetts, latitude 42° 02′ 58″.54, longitude 73° 30′ 06″.66, which is the northwest corner of the State of Connecticut; thence along the south boundary of Massachusetts, north 89° 08′ 41″ west, 40 chains; thence north 12° 57′ 16″ west 207.49^5 chains to a marble post marked on the east side M. S., on the west side N. Y., and on the south side 1853, which is in the line run by United States commissioners in 1787; thence north 15° 12′ 9″ east on the line run by said United States commissioners ([6]47 miles 73.70^5 chains) to a red or black oak tree marked by said United States commissioners, in the south boundary of the State of Vermont, latitude 42° 44′

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[6] This distance has been obtained by subtracting the length of the west line of Boston Corner given in survey of 1853 from the entire length of west boundary of Massachusetts as given by the United States commissioners in 1787.

45″.58, longitude 73° 16′ 17″.68. [See Revised Statutes of New York, 1875, page 122; also plat of survey of Boston Corner in 1853, a copy of which is on file in office of clerk of House of Representatives at Washington, D. C.]

RHODE ISLAND.

The present State of Rhode Island was settled by Roger Williams and other immigrants, who left Massachusetts Bay and established themselves at Providence in 1636.

In 1643 a patent was granted for the Providence Plantation, from which the following are extracts, viz:

* * * * * * *

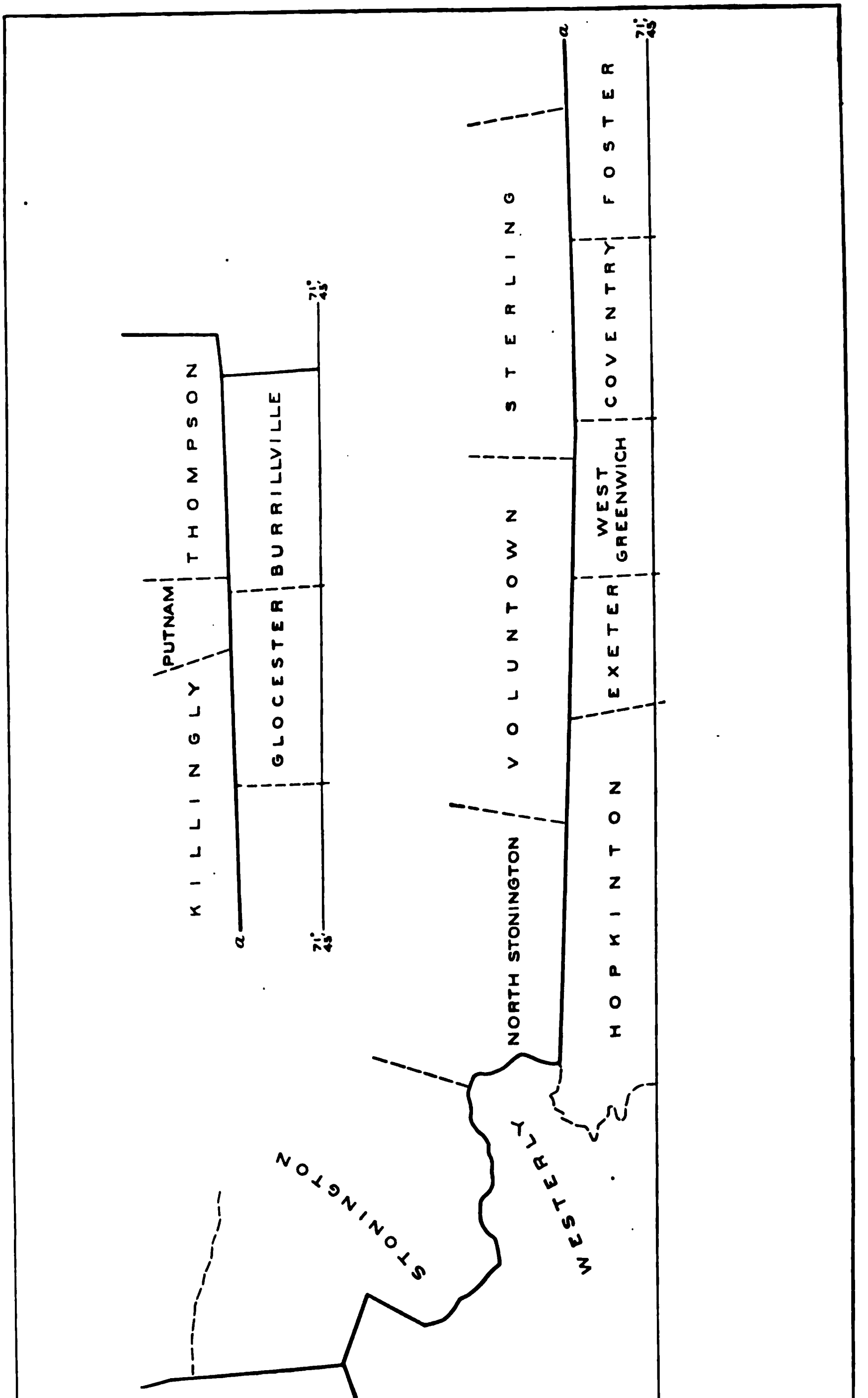
And wheras there is a tract of land in the continent of America aforesaid, called by the name of the Narraganset Bay, bordering northward and northeast on the patent of the Massachusetts, east and southeast on Plymouth patent, south on the ocean, and on the west and northwest by the Indians called Nariggannencks, alias Narragansets, the whole tract extending about 25 English miles unto the Pequot River and country; and wheras divers English inhabitants of the towns of Providence, Portsmouth, and Newport, in the tract aforesaid, * * * have represented their desire, * * * we * * * do * * * give, grant, and confirm to the aforesaid inhabitants of the towns of Providence, Portsmouth, and Newport a firm and absolute charter of incorporation, to be known by the name of the incorporation of Providence Plantations, in the Narraganset Bay, in New England. * * *

In 1663 Charles II granted a charter to Rhode Island and Providence Plantations, of which the following is an extract:

* * * "All that parte of our dominiones in New-England, in America, conteyneing the Nahantick and Narragansett Bay, and countryes and partes adjacent, bounded on the west, or westerly, to the middle or channel of a river there, commonly called and known by the name of Pawcatuck, alias Pawcawtuck river, and soe along the sayd river, as the greater or middle streame thereof reacheth or lyes upp into the north countrye, northward, unto the head thereof, and from thence, by a streight lyne drawn due north untill itt meets with the south lyne of the Massachusetts Collony; and on the north, or northerly, by the aforesayd south or southerly lyne of the Massachusetts Collony or Plantation, and extending towards the east, or eastwardly, three English miles to the east and north-east of the most eastern and north-eastern parts of the aforesayd Narragansett Bay, as the sayd bay lyeth or extendeth itself from the ocean on the south, or southwardly, unto the mouth of the river which runneth towards the towne of Providence, and from thence along the eastwardly side or banke of the sayd river (higher called by the name of Seacunck river), up to the ffalls called Patuckett ffalls, being the most westwardly lyne of Plymouth Collony, and soe from the sayd ffalls, in a streight lyne, due north, untill itt meet with the aforesayd line of the Massachusetts Collony; and bounded on the south by the ocean." And in particular, the lands belonging to the townes of Providence, Pawtuxet, Worwicke, Nusquammack, alias Pawcatuck, and the rest upon the main land in the tract aforesayd together with Rhode Island, Blocke Island, and all the rest of the islands and banks in the Narragansett Bay and bordering upon the coast of the tracts aforesaid (Ffishers Island only excepted). * * *

(For history of the northern and eastern boundaries see Massachusetts, p. 54.)

In 1703 substantially the present western boundary was settled by an agreement made between the commissioners from the two colonies f Rhode Island and Connecticut, viz: "A straight line from the mouth



BOUNDARY BETWEEN RHODE ISLAND AND CONNECTICUT

of Ashawoga River to the southwest corner of the Warwick purchase, and thence a straight north line to Massachusetts.

The line of 1703 was actually run by Rhode Island, and is still known as the Dexter and Hopkins line.

The two colonies disagreeing, Rhode Island appealed to the King, and the agreement of 1703 was finally established in 1726.

In September, 1728, commissioners from the two colonies met and ran the line.

(For agreement of 1703 and 1728, decisions of English council, etc., see R. I. Hist. Soc. Coll., Vol. III.)

In 1839 commissioners were appointed by Rhode Island and Connecticut to survey and ascertain the line and erect monuments.

The following line was established, viz:

> Beginning at a rock near the mouth of Ashawoga River, where it empties into Pawcatuck River, and from said rock a straight course northerly to an ancient stone heap at the southeast corner of the town of Voluntown, and from said rock southerly in the same course with the aforesaid line, until it strikes Pawcatuck River. From the southeast corner of Voluntown a straight line to a stone heap at the southwest corner of West Greenwich; from thence a straight line to the southwest corner of the ancient town of Warwick, and which is now a corner of the towns of Coventry and West Greenwich; from thence a straight line to the northwest corner of the town of Coventry; thence a straight line to the northeast corner of Sterling; thence a straight line to the southwest corner of Burrillville, and thence a straight line to a stone heap upon a hill in the present jurisdictional line between the States of Massachusetts and Rhode Island, and at all of said corners, excepting said Warwick corner, we have erected monuments of stone, marked R. I. and C., and have also placed similar monuments on all the principal roads crossing the line, and at other suitable places.
>
> * * * * * * *
>
> And we have caused the ancient monument which was erected at the Warwick corner in November, 1742, to be reset and a large heap of stones to be made around it. Said monument is marked with the letter C. on one side, and on the other RHODE. ISLAND and the traces of other letters and figures. [Extract from Commissioner's Report. See R. I. Acts and Resolves, Jan. 1846, pages 12, 13, 14.]

The above was ratified in 1846.

CONNECTICUT.

The title by which the people of Connecticut held the country was founded on the old patent granted by Robert, Earl of Warwick, in 1631, to Lord Say and Seal, Lord Brooke, Sir Richard Saltonstall, and others, associated under the name of the Plymouth Company.

In 1630 the Plymouth Council made a grant of Connecticut to the Earl of Warwick, their president. This was confirmed by King Charles in 1631, and on the 19th of March, in the same year, the Earl conveyed his title to the Plymouth Company, as before stated. (Dwight's Conn., p. 19, *et seq.*)

A charter was granted by Charles II to Connecticut in 1662, of which the following is an extract, viz:

* * * * * * *

> We * * * do give, grant and confirm unto the said Governor and Company, and their successors, all that part of our Dominions in New England in America bounded on the east by Narraganset River, commonly called Narraganset Bay, where the said river falleth into the sea, and on the north by the line of the Massachusetts plantation; and on the south by the sea; and longitude as the line of the Massachusetts Colony, running from east to west, that is to say, from the said Narragansett Bay on the east, to the south sea on the west part, with the islands thereunto adjoining. * *
>
> * * * * * * *
>
> [C. and C., p. 256-7.]

Previous to this time the two colonies of Connecticut and New Haven had continued separate, but under this charter they were united and the charter was accepted April 20, 1665. (C. and C., p. 252.)

The Duke of York having been granted a charter in 1664, by which the lands west of the Connecticut River were embraced in his jurisdiction, the question of boundary immediately arose.

About this time Col. Richard Nichols, George Cartwright, esq., Sir Robert Carr, and Samuel Maverick, esq., had been appointed commissioners by the King, and clothed with extraordinary powers, to determine all controversies in the colonies. The matter was referred to them, who, after a full hearing, determined that the southern boundary of Connecticut was the sea (Long Island Sound), and its western, Mamaroneck River, and a line drawn north-northwest from the head of salt water in it to Massachusetts. The territory south and west of these lines was declared to belong to the Duke of York. (*Vide* Dwight's Connecticut, pp. 159 *et seq.*)

This decision, in effect, decided upon a line 20 miles east of the Hudson River as the boundary, having for a starting point a place on Mamaroneck River.

In 1674 the Duke of York received a new charter in substantially the same terms as that of 1664. New controversies concerning jurisdiction led to a new agreement, by which it was stipulated that a tract of land on Long Island Sound, the bounds of which were described as containing 61,440 acres, should be permanently set off to Connecticut by New York on condition that the former, in exchange, should set off to New York a territory of like extent and of uniform width from the tract on the Sound to the south line of Massachusetts. This agreement was sanctioned by a royal ordinance of the King, and in 1684 the tract on the Sound was surveyed and set off to Connecticut.

The western boundary of Connecticut was run in 1685 by Major Gould, Mr. Barr, and Mr. Selleck, and ratified by both parties. (*Vide* Dwight's Connecticut, p. 199.)

For various reasons the survey of the equivalent lands was not made at that time.

In 1725 commissioners were appointed on both sides to fix the line, this being the fifth set appointed for the same purpose, none of which had been able to come to an agreement.

The commissioners of 1725, however, entered into articles of agreement settling the manner of the survey. They, however, ran only the line bounding the tract on Long Island Sound.

For some cause action was then suspended until 1731, when the commissioners of 1725 surveyed and set off the oblong or equivalent territory to New York, defining and marking its boundary, which was to remain forever the dividing line between the respective States (then colonies). The line was substantially as at present, and is as follows, viz:

> Beginning at Lyon's Point, in the mouth of a brook or river called Byram's River, where it falls into Long Island Sound, and running thence up along said river to a rock at the ancient road or wading-place in said river, which rock bears north twelve degrees and forty-five minutes east, five hundred and fifty rods from said point; then north twenty-three degrees and forty-five minutes west, two thousand two hundred and ninety-two rods; then east-northeast, thirteen miles and sixty-four rods, which lines were established in the year one thousand seven hundred and twenty-five, by Francis Harrison, Cadwaller Colden, and Isaac Hicks, commissioners on the part of the then province of New York, and Jonathan Law, Samuel Eells, Roger Walcott, John Copp, and Edmund Lewis, commissioners on the part of the then colony of Connecticut, and were run as the magnetic needle then pointed; then along an east-northeast continuation of the last-mentioned course, one mile, three-quarters of a mile, and twenty-one rods, to a monument erected in the year one thousand seven hundred and thirty-one by Cadwaller Colden, Gilbert Willett, Vincent Matthews, and Jacobus Bruyn, jr., commissioners on the part of said province, and Samuel Eells, Roger Walcott, and Edmund Lewis, commissioners on the part of said colony, which said monument is at the southeast corner of a tract known and distinguished as the oblong or equivalent lands; then north twenty-four degrees and thirty minutes west, until intersected by a line run by said last-mentioned commissioners, on a course south twelve degrees and thirty minutes west, from a monument erected by them in the south bounds of Massachusetts, which monument stands in a valley in the Taghkanick Mountains, one hundred and twenty-one rods eastward from a heap of stones in said bounds, on the top or ridge of the most westerly of said mountains; then north twelve degrees and thirty minutes east from a monument erected by said last-mentioned commissioners at said place of intersection, and standing on the north side of a hill, southeasterly from the easternmost end of the long pond, along the aforesaid line to the aforesaid monument erected in the south bounds of Massachusetts—being the northeast corner of the oblong. (See Revised Statutes of N. Y., 1881, Vol. I, pages 128-9.)

For more than a century no controversy arose, but subsequent to 1850 questions of jurisdiction were raised, and in 1855 Connecticut made a proposition for a new survey. Several sets of commissioners were appointed, but no agreement being reached, finally, in 1860, pursuant to an act of the legislature of New York, the line was run by the New York commissioners, Connecticut not being represented.

The first section of the act of the New York legislature is as follows, viz:

> 1. The commissioners appointed by the governor to ascertain the boundary line between the States of New York and Connecticut are hereby empowered and directed

to survey and mark, with suitable monuments, the said line between the two States *as fixed by the survey of* 1731.

The following is an abstract of the engineer's report of the line run under direction of the commissioners from New York, the Connecticut commissioners declining to be present or assist, viz:

Beginning at the northwest corner of Connecticut, at the monument erected by the commissioners of New York and Connecticut in 1731, latitude 42° 02′ 58″.54, longitude 73° 30′ 06″.66; thence south 11° 20′ west, 464 chains, to the [7]47th mile monument; thence south 12° 34′ west, 239 chains, 57 links, to the 44th mile monument point; thence south 11° 33′ west, 160 chains 99 links, to the 42d mile monument; thence south 13° 16′ west, 161 chains 24 links, to the 40th mile monument point; thence south 12° 21′ west, 398 chains 21 links, to the 35th mile monument; thence south 12° 32′ west, 158 chains 96 links, to the 33d mile monument; thence south 11° 44′ west, 243 chains 37 links, to the 30th mile monument; thence south 12° 27′ west, 161 chains 32 links, to the 28th mile monument; thence south 10° 56′ west, 160 chains, to the 26th mile monument point; thence south 11° 39′ west, 320 chains 11 links, to the 22d mile monument; thence south 12° 18′ west, 163 chains 17 links, to the 20th mile monument; thence south 11° 49′ west, 159 chains 9 links, to the 18th mile monument; thence south 12° 19′ west, 157 chains 15 links, to the 16th mile monument; thence south 10° 11′ west, 161 chains 7 links to the 14th mile monument; thence south 10° 51′ west, 313 chains 41 links, to the 10th mile monument point; thence south 12° 24′ west, 155 chains 71 links, to the 8th mile monument; thence south 10° 19′ west, 159 chains 28 links, to the 6th mile monument point; thence south 12° 10′ west, 164 chains 42 links, to the 4th mile monument; thence south 11° 44′ west, 158 chains 99 links, to the 2-mile monument; thence south 14° 10′ west, 109 chains 41 links, to the Ridgefield angle monument;[8] thence south 25° 8′ east, 213 chains 39 links, to the 4th mile monument on the east line of the oblong between the Wilton and Ridgefield angles; thence south 24° 48′ east, 157 chains 63 links, to the 2-mile monument; thence south 24° 14′ east, 167 chains 28 links, to the Wilton angle monument, or southeast corner of the oblong as set off by the commissioners of 1731; thence south 67° 45′ west, 138 chains 76 links, to the southwest corner of the oblong, and being where the survey of 1725 terminated; thence south 65° 44′ west, 90 chains 87 links, to a point considered the original 12th mile monument point; thence south 66° 56′ west, 241 chains 93 links, to a point called the 9th mile monument; thence south 66° 45′ west, 319 chains 12 links, to the 5th mile monument point; thence south 66° 25′ west, 398 chains 40 links, to the angle at the Duke's

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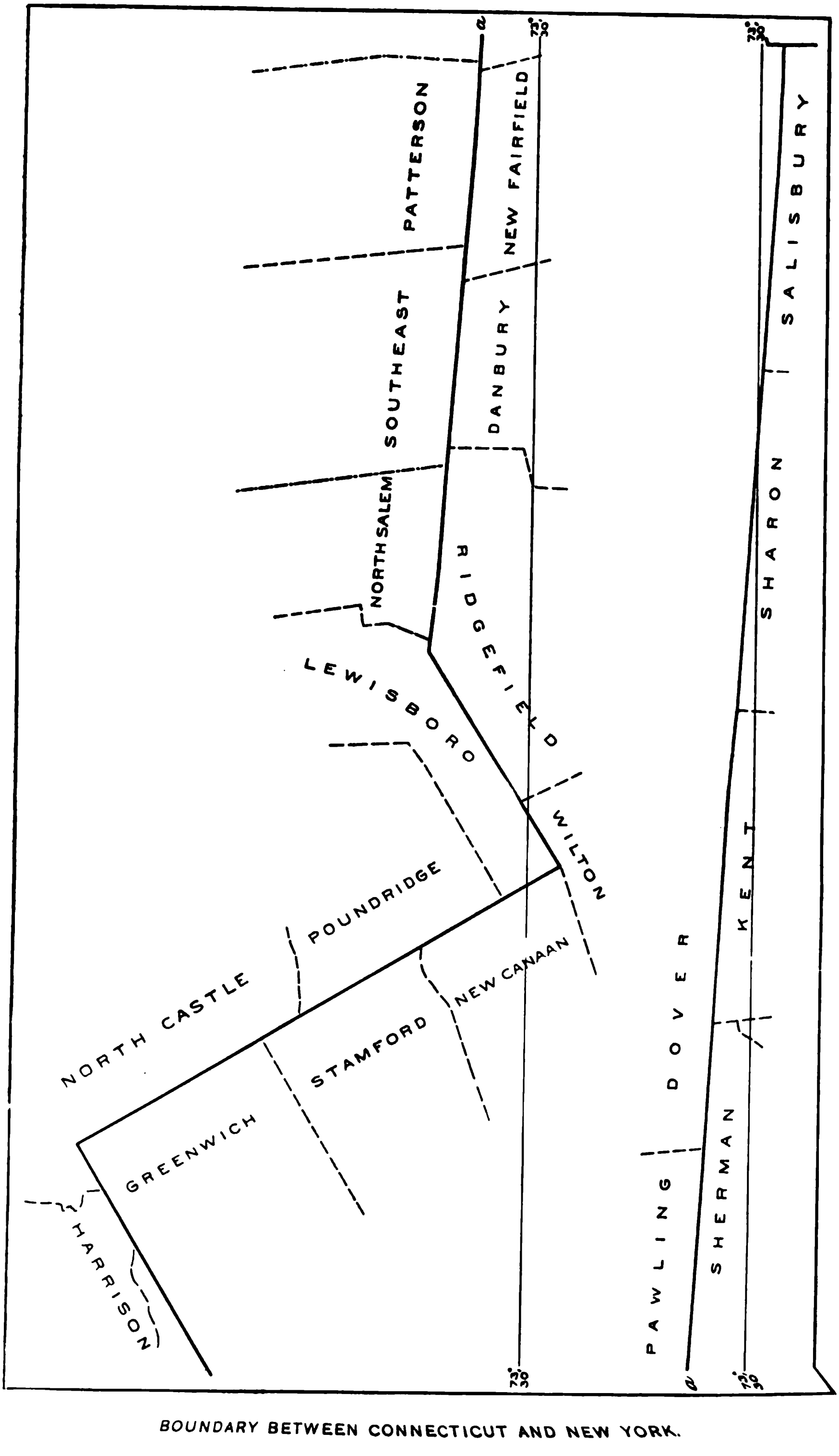
[7] The mile monuments referred to are those, at that time remaining, which were established by the Connecticut and New York commissioners of 1731.

[8] The entire distance from the Massachusetts line to Ridgefield angle is 52 miles 35 rods, a difference of only 5 rods from the survey of 1731.



BOUNDARY BETWEEN CONNECTICUT AND NEW YORK.

Trees; thence south 23° 38′ east, 172 chains 93 links, to a point which is west-southwest and distant 32 rods from the chimney in the old Clapp house; thence south 24° 21′ east, 224 chains 78 links, to a point opposite the old William Anderson house; thence south 24° 19′ east, 173 chains 7 links, to the great stone at the ancient wading place on Byrom River; thence south 17° 45′ west, 12 chains 60 links, to a rock in the river which can be seen at low tide, in which there is a bolt; thence south 27° west, 55 chains 19 links; thence south 7° 20′ east, 13 chains 45 links; thence south 12° 10′ east, 16 chains 13 links; thence south 2° 40′ east, 9 chains 4 links; thence south 28° 25′ east, 9 chains 54 links; thence south 18° 40′ east, 4 chains 77 links; thence south 11° 55′ west, 6 chains 33 links; thence south 58° 10′ west, to where it falls into the sound. (See report of the commissioners to ascertain and settle the boundary line between the States of New York and Connecticut, February 8, 1861, in which will also be found a complete account of this controversy.)

In 1880 commissioners were appointed by Connecticut and New York. Their report was ratified in 1880.

These commissioners reported as follows, viz:

> We agree that the boundary on the land constituting the western boundary of Connecticut and the eastern boundary of New York shall be and is as the same was defined by monuments erected by commissioners appointed by the State of New York, and completed in the year 1860, the said boundary line extending from Byram Point, formerly called Lyon's Point, on the south, to the line of the State of Massachusetts on the north.
>
> And we further agree that the boundary on the sound shall be and is as follows: Beginning at a point in the center of the channel, about 600 feet south of the extreme rocks of Byram Point, marked No. 0, on appended United States Coast Survey chart; thence running in a true southeast course 3½ statute miles; thence in a straight line (the arc of a great circle) northeasterly to a point 4 statute miles due south of New London Light-House; thence northeasterly to a point marked No. 1, on the annexed United States Coast Survey chart of Fisher's Island Sound, which point is on the longitude east three-quarters north, sailing course down on said map, and is about 1,000 feet northerly from the Hommock or North Dumpling Light-House; thence following said east three-fourths north sailing course as laid down on said map, easterly to a point marked No. 2 on said map; thence southeasterly to a point marked No. 3 on said map; so far as said States are coterminous. (See Revised Statutes of New York, 1881, Vol., I, page 136.)

The above agreement concerning these boundaries between Connecticut and New York was confirmed by the Congress of the United States on February 26, 1881. (See Revised Statutes of United States, 1881.)

(For the history and present location of the eastern boundary of Connecticut, *vide* Massachusetts, p. 61, and Rhode Island, p. 70. For the northern boundary, *vide* Massachusetts, p. 64.)

Under the charter of 1662 Connecticut claimed a large western territory. Subsequent to the Revolution, however, in 1786, 1792, 1795, and 1800, she relinquished all title to any land west of her present boundary.

NEW YORK.

The territory included in the present State of New York was embraced in the French and English grants of 1603 and 1606. The Dutch, however, in 1613 established trading posts on the Hudson River and claimed jurisdiction over the territory between the Connecticut and Delaware Rivers, which they called New Netherlands. The government was vested in "The United New Netherland Company," chartered in 1616, and then in "The Dutch West India Company," chartered in 1621.

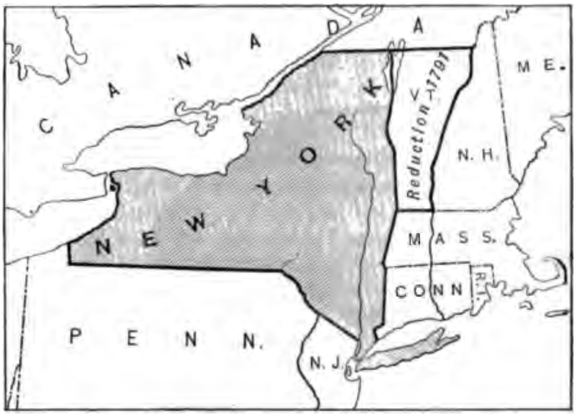
In 1664 King Charles II of England granted to his brother, the Duke of York, a large territory in America, which included, with other lands, all that tract lying between the west bank of the Connecticut River and the east bank of the Delaware. The Duke of York had previously purchased, in 1663, the grant of Long Island and other islands on the New England coast, made in 1635 to the Earl of Stirling, and in 1664, with an armed fleet, he took possession of New Amsterdam, which was thenceforth called New York. This conquest was confirmed by the treaty of Breda, in 1667.

The following is an extract from the grant of 1664 to the Duke of York:

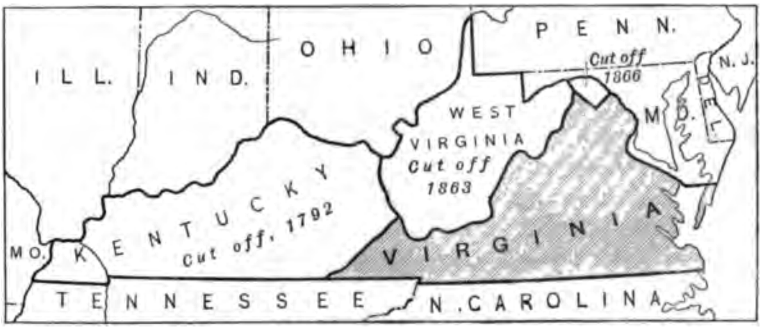
> All that parte of the maine land of New England beginning at a certaine place called or knowne by the name of St. Croix next adjoyning to New Scotland in America and from thence extending along the sea coast unto a certain place called Petuaquine or Pemaquid and so up the River thereof to the further head of ye same as it tendeth northwards and extending from thence to the River Kinebequi and so upwards by the shortest course to the River Canada northward and also all that Island or Islands commonly called by the severall name or names of Matowacks or Long Island scituate lying and being towards the west of Cape Codd and ye narrow Higansetts abutting upon the maine land between the two Rivers there called or knowne by the severall names of Conecticutt and Hudsons River togather also with the said river of Hudsons River and all the land from the west side of Conecticutt to ye east side of Delaware Bay and also all those severall Islands called, or knowne by the names of Martin's Vinyard and Nantukes otherwise Nantuckett togather with all ye lands islands soyles harbours mines minerals quarryes woods marshes waters lakes ffishings hawking hunting and ffowling and all other royalltyes proffitts commodityes and hereditaments to the said severale island lands and premisses belonging and appertaining with theire and every of theire appurtenances and all our estate right title interest benefitt advantage claime and demand of in or to the said lands and premises or any part or parcell thereof and the revercon and revercons remainder and remainders togather with the yearly and other ye rents revenues and proffitts of all and singular the said premisses and of every part and parcell thereof to have and to hold all and singular the said lands islands hereditaments and premisses with their and every of their appurtenances.

In July, 1673, the Dutch recaptured New York and held it until it was restored to the English by the treaty of Westminster, in February, 1674.

The Duke of York thereupon, to perfect his title, obtained a new



HISTORICAL DIAGRAM OF NEW YORK.



HISTORICAL DIAGRAM OF VIRGINIA.

grant, in substantially the same terms as that of 1664 (C. and C., p. 1328), of which the following is an extract, viz:

* * * * * * *

> All that part of the main land of New England, beginning at a certain place called or known by the name of Saint Croix nexe adjoining to New Scotland in America, and from thence extending along the sea-coast into a certain place called Petuaquim or Pemquid, and so up the river thereof to the furthest head of the same as it windeth northward and extending from the river of Kinebequ and so upwards by the shortest course to the river Canada northwards; and all that island or islands commonly called by the several name or names of Matowacks or Long Islands, situate and being toward the west of Cape Cod and the narrow Higansuts abutting upon the main land between the two rivers there called or known by the several names of Connecticut and Hudson Rivers, together also with the said river called Hudson's River, and all the lands from the west side of Connecticut River to the east side of Delaware Bay; and also all those several islands called or known by the names of Martin Vinyard and Nantukes, otherwise Nantuckett.

* * * * * * *

By these grants to the Duke of York and the conquest of the Dutch possessions in America, it will be seen that New York originally had a claim to a much larger territory than is now included in her limits. The successive changes in her extent may be sketched as follows, viz:

In 1664 the Duke of York sold the present State of New Jersey to Lord John Berkeley and Sir George Carteret.

In 1682 the Duke of York sold to William Penn his title to Delaware and the country on the west bank of the Delaware, which had been originally settled by the Swedes, then conquered by the Dutch, and which had by them been surrendered to the Duke of York.

In 1686 Pemaquid and its dependencies were annexed to the New England government by a royal order, the Duke of York having acceded to the throne of England.

By the charter of 1691 to Massachusetts Bay, all claim to any part of Maine was extinguished, and the islands of Nantucket, Marthas Vineyard, and others adjacent (hitherto known as Duke's County, New York), were annexed to Massachusetts Bay.

The territory west of the Connecticut River to within about 20 miles of the Hudson River, now forming a portion of Massachusetts and Connecticut, were, by agreements and concessions made at various periods, surrendered to those States respectively.

In 1781 New York released to the General Government all the lands to which she had claim west of a meridian extending through the west extremity of Lake Ontario, and in 1790 she gave up all claim to the present State of Vermont and consented to her independence.

By these successive reductions New York was left with substantially her present boundaries.

(For the history and settlement of the eastern boundary of New York, *vide* Vermont, Massachusetts, and Connecticut, *ante* pp. 52, 68, and 72.)

The northern boundary was settled by the treaty of peace in 1783 and by the commission under the sixth article of the treaty of Ghent. (*Vide* p. 13.)

The boundary between New York and New Jersey was plainly stated in the grant by the Duke of York to Berkeley and Carteret. (*Vide* New Jersey, p. 82.)

In 1719 attempts were made to have the line run and marked, but nothing seems to have been done to settle the matter permanently till 1769, when commissioners were appointed by the King, who fixed on substantially the present line. (*Vide* R. S. N. J., 1821, pp. 29–34.)

In 1772 this line was confirmed by the legislatures of both colonies, and commissioners were appointed to survey and mark the same.

This line was as follows, viz:

> A direct and straight line from the fork or branch formed by the junction of the stream or waters called the Machackamack with the river Delaware or Fishkill, in the latitude of 41° 21′ 37″, to a rock on the west side of the Hudson River, marked by the said surveyors in the latitude of 41°—said rock was ordered to be marked—with the following words and figures, viz: "Latitude 41° north;" and on the south side thereof "New Jersey"; and on the north side thereof "New York"; also, to mark every tree that stood on the line with five notches and a blaze on the northwest and southeast sides thereof, and to put up stone monuments, at 1 mile distance from each other, along the said line, and to number such monuments with the number of miles; the same shall be from the before-mentioned marked rock on the west side of Hudson's River, and mark the words "New Jersey" on the south side, and the words "New York" on the north side, of every of the said monuments. (See R. S. of N. J., 1821, pp. 29–34.)

The above was confirmed by the king in council September 1, 1773.

In the year 1833 commissioners were appointed by New York and New Jersey for the settlement of the territorial limits and jurisdiction of the two States.

In the following year the commissioners made the following agreement, which was ratified by each State and confirmed by Congress, viz:

UNITED STATES STATUTES AT LARGE. TWENTY-THIRD CONGRESS, SESSION I. 1834.

AN ACT giving the consent of Congress to an agreement or compact entered into between the State of New York and the State of New Jersey, respecting the territorial limits and jurisdiction of said States.

ARTICLE FIRST. The boundary line between the two States of New York and New Jersey, from a point in the middle of Hudson River, opposite the point on the west shore thereof, in the forty-first degree of north latitude, as heretofore ascertained, and marked, to the main sea, shall be the middle of the said river, of the bay of New York, of the waters between Staten Island and New Jersey and of Raritan Bay, to the main sea; except as hereinafter otherwise particularly mentioned.

ARTICLE SECOND. The State of New York shall retain its present jurisdiction of and over Bedloe's and Ellis's Islands, and shall also retain exclusive jurisdiction of and over the other islands lying in the waters above mentioned and now under the jurisdiction of that State.

ARTICLE THIRD. The State of New York shall have and enjoy exclusive jurisdiction of and over all the waters of Hudson River lying west of Manhattan Island and to the south of the mouth of Spuytenduyvel Creek; and of and over the lands covered by the said waters to the low-water mark on the westerly or New Jersey side thereof; sub-

ject to the following rights of property and of jurisdiction of the State of New Jersey, that is to say:

1. The State of New Jersey shall have the exclusive right of property in and to the land under water lying west of the middle of the bar of New York, and west of the middle of that part of the Hudson River which lies between Manhattan Island and New Jersey.

2. The State of New Jersey shall have the exclusive jurisdiction of and over the wharves, docks, and improvements made and to be made on the shore of the said State; and of and over all vessels aground on said shore, or fastened to any such wharf or dock, except that the said vessels shall be subject to the quarantine or health laws, and laws in relation to passengers, of the State of New York, which now exist or which may hereafter be passed.

3. The State of New Jersey shall have the exclusive right of regulating the fisheries on the westerly side of the middle of said waters: *Provided*, That the navigation be not obstructed or hindered.

ARTICLE FOURTH. The State of New York shall have exclusive jurisdiction of and over the waters of the Kill Von Kull between Staten Island and New Jersey to the westernmost end off Shorter's Island in respect to such quarantine laws, and laws relating to passengers, as now exist or may hereafter be passed under the authority of that State, and for executing the same; and the said State shall also have exclusive jurisdiction, for the like purposes, of and over the waters of the sound from the westernmost end of Shorter's Island to Woodbridge Creek, as to all vessels bound to any port in the said State of New York.

ARTICLE FIFTH. The State of New Jersey shall have and enjoy exclusive jurisdiction of and over all the waters of the sound between Staten Island and New Jersey lying south of Woodbridge Creek, and of and over all the waters of Raritan Bay lying westward of a line drawn from the light-house at Prince's Bay to the mouth of Mattavan Creek; subject to the following rights of property and of jurisdiction of the State of New York, that is to say:

1. The State of New York shall have the exclusive right of property in and to the land under water lying between the middle of the said waters and Staten Island.

2. The State of New York shall have the exclusive jurisdiction of and over the wharves, docks, and improvements made and to be made on the shore of Staten Island, and of and over all vessels aground on said shore, or fastened to any such wharf or dock; except that the said vessels shall be subject to the quarantine of health laws, and laws in relation to passengers of the State of New Jersey which now exist or which may hereafter be passed.

3. The State of New York shall have the exclusive right of regulating the fisheries between the shore of Staten Island and the middle of said waters: *Provided*, That the navigation of the said waters be not obstructed or hindered.

* * * * * * *

In 1876 commissioners were appointed to re-locate the land boundary between New York and New Jersey, and replace monuments that may have become dilapidated or removed, or to erect new ones, etc. (*Vide* Rev. of N. J., 1877.)

The above commissioners found in some cases a slight discrepancy between the original marks and the verbal description thereof, and the legislatures of each State ordered that the original monuments should be considered the true boundary. (*See* acts of New York, 1880, and acts of New Jersey, 1881.)

In 1881 a joint commission of the two States was appointed for the purpose of retracing and remarking, in a permanent manner, this boundary. This work was completed in a thorough manner in 1883.

In 1887 a joint commission of the two States was appointed to determine and mark the boundary between the two States, through Raritan Bay. This commission came to an agreement, the terms of which are as follows:

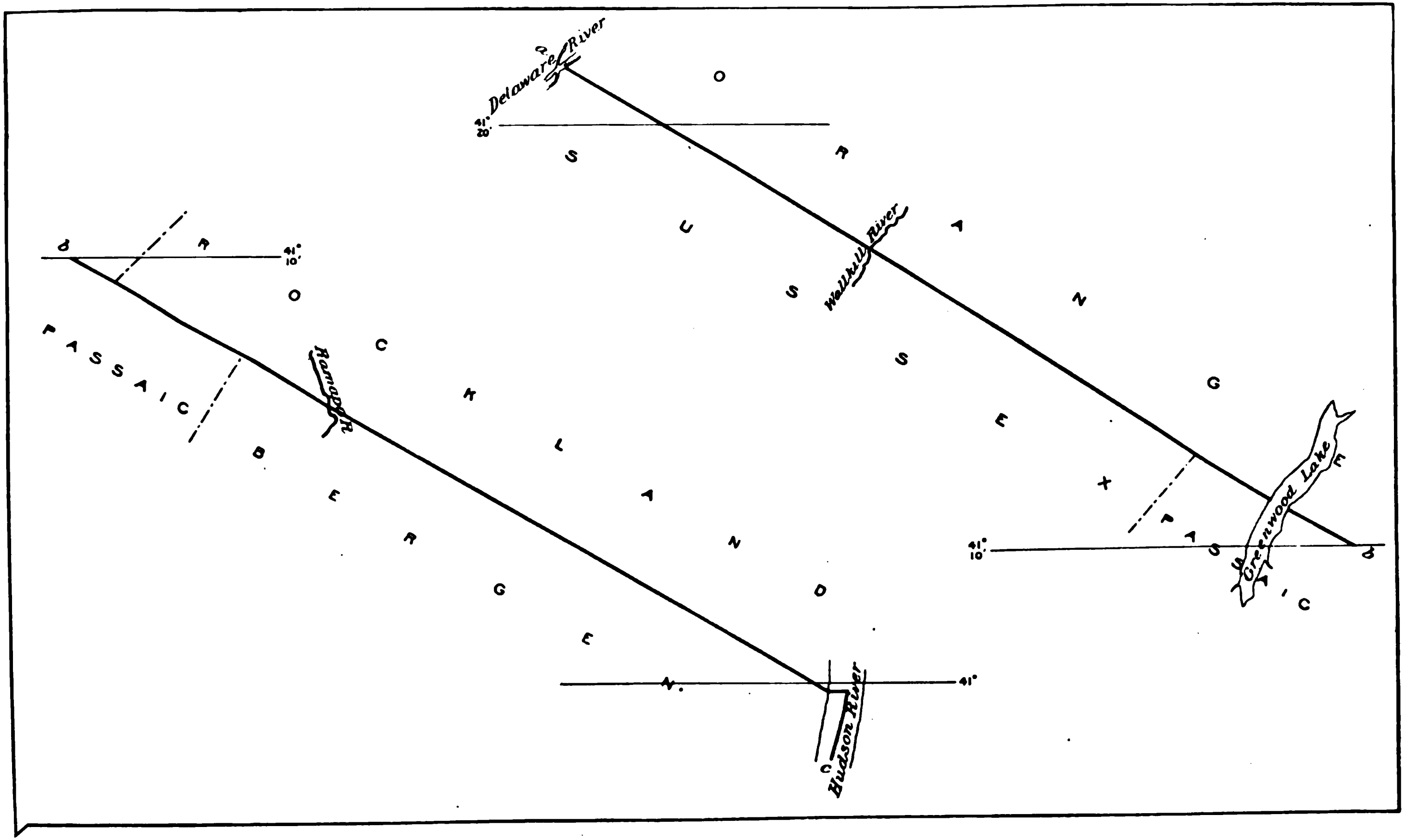
First. From "Great Beds light-house," in Raritan Bay, north, twenty degrees sixteen minutes west, true, to a point in the middle of the waters of Arthur Kill, or Staten Island Sound, equidistant between the southwesterly corner of the dwelling house of David C. Butler, at Ward's Point, on Staten Island, in the State of New York, at the southeasterly corner of the brick building on the lands of Cortlandt L. Parker, at the intersection of the westerly line of Water street with the northerly line of Lewis street, in Perth Amboy, in the State of New Jersey.

Second. From "Great Beds light-house" south, sixty-four degrees and twenty-one minutes east, true (S. 64° 21′ E.), in line with the center of Waackaack or Wilson's beacon, in Monmouth County, New Jersey, to a point at the intersection of said line with a line connecting "Morgan No. 2" triangulation point, U. S. Coast and Geodetic Survey, in Middlesex County, New Jersey, with the "Granite and Iron beacon," marked on the accompanying maps as "Romer stone beacon," situated on the "Dry Romer shoal;" and thence on a line bearing north, seventy-seven degrees and nine minutes east, true (N. 77° 9′ E.), connecting "Morgan No. 2" triangulation point, U. S. Coast and Geodetic Survey, in Middlesex County, New Jersey, with said "Romer stone beacon" (the line passing through said beacon and continuing in the same direction), to a point at its intersection with a line drawn between the "Hook beacon," on Sandy Hook, New Jersey, and the triangulation point of the U. S. Geodetic Survey, known as the Oriental Hotel, on Coney Island, New York; then southeasterly, at right angles with the last mentioned line to the main sea.

Third. The monumental marks by which said boundary line shall be hereafter known and recognized are hereby declared to be as follows:

1. The "Great Beds light-house."
2. A permanent monument marked "State boundary line New York and New Jersey," and to be placed at the intersection of the line drawn from the "Great Beds light-house" to "Waackaack or Wilson's beacon," Monmouth County, New Jersey, and the line drawn from "Morgan No. 2" triangulation point, U. S. Coast and Geodetic Survey, in Middlesex County, New Jersey, to "Romer stone beacon."
3. Eight buoys or spindles, to be marked like the permanent monument above mentioned, and placed at suitable intervening points along the line from the said permanent monument to the "Romer stone beacon."
4. The "Romer stone beacon."

In the year 1774 commissions were appointed by New York and Pennsylvania to fix the beginning of the forty-third degree of north latitude



NORTHEAST BOUNDARY OF NEW JERSEY.

on the Mohawk or western branch of Delaware River, which is the northeast corner of Pennsylvania, and to proceed westward and fix the line between Pennsylvania and New York.

These commissioners reported in December of the same year that they fixed the said northeast corner of Pennsylvania, and marked it as follows, viz:

> On a small island in the said river they planted a stone marked with the letters and figures, New York, 1774, cut on the north side thereof; and the letters and figures, latitude 42° variation 4° 20′, cut on the top thereof; and in a direction due west from thence on the west side of the said branch of Delaware, collected and placed a heap of stones at the water mark; and proceeding further west four perches, planted another stone in the said line marked with the letters and figures, Pennsylvania, 1774, cut on the south side thereof, and the letters and figures, latitude 42° variation 4° 20′, cut on the top thereof, and at the distance of eighteen perches due west from the last-mentioned stone marked an ash tree. The rigor of the season prevented them running the line farther.

Nothing further seems to have been done until 1786–'7, when commissioners were appointed to finish the work thus begun (*see* Cary & Biorden's Laws of Pennsylvania, Vol. III, page 392), and the lines were run and monuments erected. The line was ratified in 1789, and is as follows, viz:

> Beginning at a point in Lake Erie, where the boundary line between the United States and Great Britain is intersected by a meridian line drawn through the most westerly bent or inclination of Lake Ontario; then south along said meridian line to a monument in the beginning of the forty-third degree of north latitude, erected in the year one thousand seven hundred and eighty-seven, by Abraham Herdenbergh and William W. Morris, commissioners on the part of this State, and Andrew Ellicott and Andrew Porter, commissioners on the part of the State of Pennsylvania, for the purpose of marking the termination of the line of jurisdiction between this State and the said State of Pennsylvania; then east along the line established and marked by said last-mentioned commissioners to the ninetieth mile-stone in the same parallel of latitude, erected in the year one thousand seven hundred and eighty-six, by James Clinton and Simeon DeWitt, commissioners on the part of this State, and Andrew Ellicott, commissioner on the part of Pennsylvania; which said ninetieth mile-stone stands on the western side of the south branch of the Tioga River; then east along the line established and marked by said last-mentioned commissioners, to a stone erected in the year one thousand seven hundred and seventy-four, on a small island in the Delaware River, by Samuel Holland and David Rittenhouse, commissioners on the part of the colonies of Pennsylvania and New York, for the purpose of marking the beginning of the forty-third degree of north latitude; then down along said Delaware River to a point opposite to the fork or branch formed by the junction of the stream called Mahackamack with the said Delaware River, in the latitude of forty-one degrees, twenty-one minutes and thirty-seven seconds north; then in a straight line to the termination on the east bank of the Delaware River of a line run in the year one thousand seven hundred and seventy-four, by William Wickham and Samuel Gale, commissioners on the part of the then colony of New York, and John Stevens and Walter Rutherford, commissioners on the part of the then colony of New Jersey. (*See* Revised Statutes of New York, 1881.)

The meridian line forming the western boundary of New York was surveyed and mapped in 1790 by Andrew Ellicott, as United States commissioner (Pa. Archives, Vol. XII—Map), and the latitude formerly inscribed on the monument on Lake Erie, fixing the western boundary, was 42° 16′ 13″. The report of the commissioner has not been found.

In 1865 Dr. Peters, director of Hamilton College Observatory, under the directions of the Regents of the University of New York, determined the latitude and longitude of the boundary monument aforesaid, with the following result: Latitude, 42° 16′ 2″.8; longitude, 79° 45′ 54″.4. (*Vide* Dr. Peters' Report, 1868.)

In 1877 the parallel of the forty-second degree north latitude was ascertained at four points, by the New York and Pennsylvania Joint Boundary Commission, with the following result, viz:

1. At Travis Station (Hale's Eddy), very near the east end of that part of the New York and Pennsylvania line supposed to be on the forty-second parallel, the old line was found to be 275 feet north of the parallel.
2. At Finn's Station, about 20 miles from east end (Great Bend), the line is 350 feet south of the parallel.
3. At Burt's Station, about 70 miles from east end (Wellsburg), the line is 760 feet north of the parallel.
4. At Clark's Station, about 253 miles from east end (Wattsburg), the line is 150 feet north of the parallel.

(See pamphlet, Report of Penn. Board of the Penn. & N. Y. Joint Boundary Comm.)

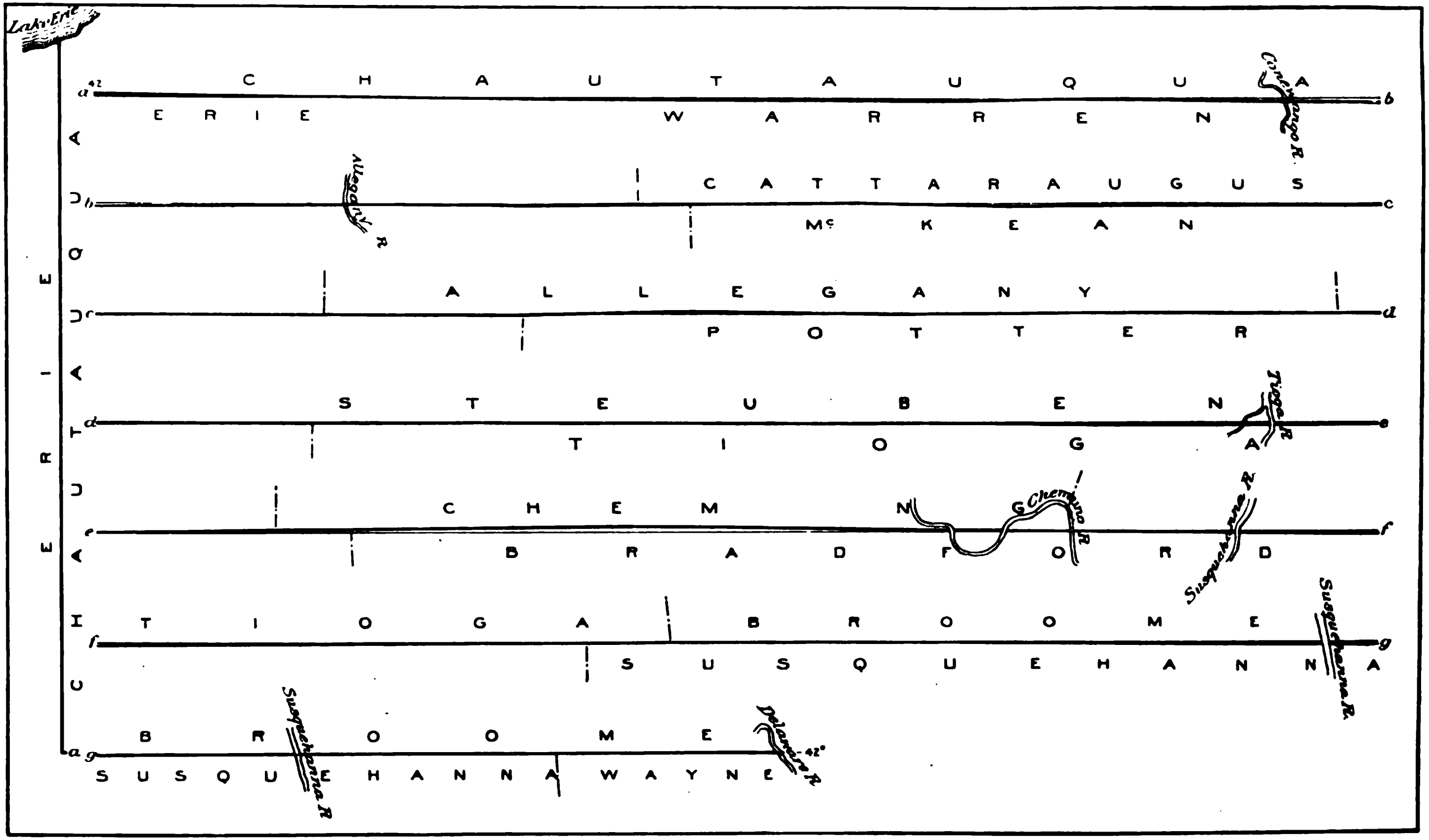
NEW JERSEY.

Although the original grants from the French and English sovereigns of 1603 and 1606 covered the territory forming the present State of New Jersey, the grant which first directly relates to New Jersey is that given in 1664 by the Duke of York to Lord John Berkeley and Sir George Carteret, two months before the setting out of his expedition to take possession of New York.

The following extract from that grant defines the boundaries, viz:

> All that tract of land adjacent to New England, and lying and being to the westward of Long Island and Manhitas Island, and bounded on the east part by the main sea and part by Hudson's River, and hath upon the west Delaware Bay or river, and extendeth southward to the main ocean as far as Cape May, at the mouth of Delaware Bay, and to the northward as far as the northernmost branch of the said bay or river of Delaware, which is forty-one degrees and forty minutes of latitude, and crosseth over thence in a strait line to Hudson's River in forty-one degrees of latitude; which said tract of land is hereafter to be called by the name or names of New Ceaserea or New Jersey. (*Vide* Grants, Concessions, etc., of New Jersey, Leaming & Spicer, p. 8.)

In March, 1673, Lord Berkeley sold his undivided moiety of New Jer[illegible]ey to John Fenwick, by whom, in the following year, it was again sold. [illegible]ly 1, 1676, was executed the famous "Quintipartite deed," by which



WESTERN AND SOUTHERN BOUNDARY OF NEW YORK.

the eastern part was given to Sir George Carteret, to be called East New Jersey, and the western part to the other proprietors, to be called West New Jersey. Sir George Carteret, at his death in 1678, left his land to be sold. It was sold in 1682 to the twelve proprietors, who admitted other partners.

Confirmation grants were made to the proprietors of both provinces by the Duke of York, and confirmed by the King, but between 1697 and 1701 the proprietors repeatedly made petitions to be allowed to surrender their right of government to the Crown. Accordingly, in 1702, the surrender was made and accepted by the Queen, and both parts united were made the province of New Jersey. (*Vide* Leaming and Spicer's grants, etc.)

(For the history of the northern and eastern boundary, *vide* New York, p. 78.)

The grant from the Duke of York to Berkeley and Carteret defined the west boundary of New Jersey to be the Delaware River. (*Vide* p. 82.)

The line between New Jersey and Delaware is thus described in the Revised Statutes of Delaware, p. 2, viz:

> Low-water mark on the eastern side of the river Delaware, within the twelve-mile circle from New Castle and the middle of the bay, below said circle.

In 1876 the legislature of New Jersey authorized the governor to commence a suit in the Supreme Court of the United States to settle the boundary between New Jersey and Delaware. New Jersey claimed jurisdiction to the middle of the Delaware, so far as the river and bay is a boundary between the two States. (*Vide* Revision of New Jersey, p. 1185.)

In 1783 Commissioners were appointed by New Jersey and Pennsylvania to settle the jurisdiction of the river Delaware and the islands within the same. Their report was ratified, and is in substance as follows:

First. It is declared that the river Delaware from the station point or northwest corner of New Jersey, northerly to the place upon the said river where the circular boundary of the State of Delaware touches upon the same, in the whole length and breadth thereof, is and shall continue to be and remain a common highway, equally free and open for the use, benefit, and advantage of the said contracting parties, etc.

Second. That each State shall enjoy and exercise a concurrent jurisdiction within and upon the water, and not upon the dry land between the shores of said river, etc.

Third. That all islets, islands, and dry land within the bed and between the shores of said river, and between said station point northerly and the falls of Trenton southerly, shall, as to jurisdiction, be hereafter deemed and considered as parts and parcels of the State to which such insulated dry land doth lie nearest at the time of making this agreement, and that from said falls of Trenton to the State of Delaware southerly, certain islands (in the agreement they are named B) be annexed to each State respectively. (*Vide* Revision of New Jersey, p. 1181.)

In 1786 commissioners were appointed by New Jersey and Pennsylvania for more accurately determining and describing the islands mentioned in the foregoing agreement; that is, those in the Delaware from the northwest corner of New Jersey down to the falls of Trenton. Their report was ratified, and a long list of islands, described by name in the act, were annexed to each State respectively. (*Vide* Revision of New Jersey, pp. 1182–'3.)

PENNSYLVANIA.

The Swedish West India Company, chartered by the King of Sweden in 1625, established the first permanent settlement on the west bank of the Delaware, occupying a part of the territory now in Pennsylvania and Delaware, although the Dutch had previously established trading posts, which had been destroyed by the Indians. The Swedes acquired, by successive purchases from the Indian chiefs, all the land extending from Cape Henlopen to the great falls of the Delaware, calling it New Sweden. (*Vide* C. and C., p. 1509.)

In 1655 this territory was surrendered to the Dutch. (*Vide* Hazard's Annals of Pennsylvania, p. 185.)

By the conquest of the New Netherlands, in 1664, the Duke of York seems to have successfully claimed the settlements on the west bank of the Delaware as a part of his dominions.

In 1681 Charles II of England granted to William Penn the Province of Pennsylvania. The following extract from the charter defines the boundaries:

> * * * all that Tracte or Parte of Land in America, with all the Islands therein conteyned, as the same is bounded on the East by Delaware River, from twelve miles distance Northwards of New Castle Towne unto the three and fortieth degree of Northerne Latitude, if the said River doeth extende so farre northwards; But if the said River shall not extend soe farre Northward, then by the said River soe farr as it doth extend; and from the head of the said River the Eastern Bounds are to bee determined by a Meridian Line, to bee drawne from the head of the said River, unto the said three and fortieth degree. The said Lands to extend westwards five degrees in longitude, to bee computed from the said Easterne Bounds; and the said Lands to bee bounded on the North by the beginning of the three and fortieth degree of Northern Latitude, and on the South by a Circle drawne at twelve miles distance from New Castle Northward and Westward unto the beginning of the fortieth degree of Northern Latitude, and thence by a streight Line Westward to the Limit of Longitude above mentioned.

William Penn, in order to perfect his title, procured of the Duke of York a deed bearing date August 21, 1682, by which the Duke of York conveyed to him all title and claim which he might have to the province of Pennsylvania. (*Vide* Hazard's Annals of Pa., 586 *et seq.*)

He also purchased of the Duke of York the territory now comprising the State of Delaware, which he held until 1701–'2, when he granted a charter which enabled them to set up a separate government, though still under proprietary control. (*Vide* C. and C., p. 270 *et seq.*)

(For a history of the northern and eastern boundaries of Pennsylvania, see New York and New Jersey, pp. 80 and 83.]

That part of the southern boundary of Pennsylvania between Pennsylvania and Delaware is an arc of a circle, having for its center the steeple of the old court-house at New Castle, Del., and a radius of 12 miles. This was surveyed and marked under a warrant from William Penn in 1701. (*Vide* Hazard's Annals of Pennsylvania.)

This circular line, in connection with adjacent lines, was made the subject of controversy for many years.

According to the original grants of Pennsylvania and Maryland the boundary between them was to be the fortieth degree of north latitude.

This line being found to pass north of Philadelphia and to exclude Pennsylvania from Delaware Bay, negotiations ensued between the proprietors to rectify this geographical blunder, and for nearly a century the matter remained unsettled.

In the year 1732 an agreement was made to fix the boundary. Commissioners were appointed in that year, and subsequently in 1739, to run the line, but they failed to agree, and chancery suits were the result. Taking a decision of Lord Chancellor Hardwick in 1750 as a basis of final adjudication, an agreement was signed July 4, 1760. By this agreement the line between Pennsylvania and Delaware on the one part and Maryland on the other was determined as follows, viz:

A due east and west line should be run across the peninsula from Cape Henlopen to the Chesapeake Bay. From the exact middle of this line should be drawn a line tangent to the western periphery of a circle, having a radius of 12 English statute miles, measured horizontally from the center of the town of New Castle. From the tangent point a line should be drawn due north until it cut a parallel of latitude 15 miles due south of the most southern part of the city of Philadelphia, this point of intersection to be the northeast corner of Maryland; thence the line should run due west on said parallel as far as it formed a boundary between the two governments. (*Vide* Delaware, p. 87.)

In 1760 commissioners and surveyors were appointed, who spent three years in measuring the base line and the tangent line between Maryland and Delaware.

The proprietors then, wearied with the delay, sent over from England two famous mathematicians, Charles Dixon and Jeremiah Mason, who verified the work of their predecessors, and ran the line west between Pennsylvania and Maryland, since known as "Mason and Dixon's line."

Mason and Dixon fixed the latitude of this line at 39° 43′ 18″. A resurvey in 1850 by Colonel Graham determined it to be 39° 43′ 26″.3.

Mason and Dixon begun their work in 1763, and were stopped by Indians in 1767, having run the line about 244 miles west of the Delaware, not quite finishing their work. They put up mile stones all along said line, every fifth one being marked with the arms of the respective proprietors.

In consequence of the accidental removal of the stone at the northeast corner of Maryland, commissioners were appointed in 1850 by Pennsylvania, Delaware, and Maryland to revise the former survey, which was done by Lieutenant-Colonel Graham, of the United States topographical engineers. The result confirmed the work of Mason and Dixon, and Maryland gained by the resurvey a little less than two acres.

(For a full report of the running of Mason and Dixon's line in 1763–'67, and the verification by Colonel Graham in 1850, see Senate Journal of Delaware for 1851, pages 56–109.)

In 1784 the report of the commissioners who had been appointed to fix the boundaries between Virginia and Pennsylvania (West Virginia then forming part of Virginia) was confirmed, and the lines so fixed are as follows, viz:

> The line commonly called Mason and Dixon's line to be extended due west five degrees of longitude from the river Delaware, for the southern boundary of Pennsylvania, and a meridian drawn from the western extremity thereof to the northern limits of the said States, respectively, be the western boundary of Pennsylvania. (*Vide* C. and B. laws of Pennsylvania, Vol. II, p. 495, and Hening's Virginia, Vol. XI, p. 554.)

By the cession of 1784, by Virginia to the United States—and that of 1800, by Connecticut to the United States, and the formation of the State of West Virginia from a portion of Virginia in 1862—the above-mentioned meridian line becomes the boundary between Pennsylvania on the east, and Ohio and West Virginia on the west.

By an examination of the cession of 1781, by New York to the United States, it will be seen that a small triangular tract on Lake Erie was left in the hands of the General Government. This was sold to Pennsylvania in 1792.

DELAWARE.

The State of Delaware was originally settled by the Swedes. (*Vide* Pennsylvania, p. 84.) In 1655 it was surrendered to the Dutch, who, in 1664, in turn surrendered it to the English, and it was taken possession of by the Duke of York.

William Penn, having received in 1682 a grant of the province of Pennsylvania, bought of the Duke of York the territory comprising the present State of Delaware It was conveyed to him by two deeds of feoffment, dated August 24, 1682, one conveying the town of New Castle and a twelve-mile circle around the same, and the other conveying all the lands south of said circle to Cape Henlopen. (See Hazard's Annals of Pennsylvania, p. 588, *et seq.*)

Soon after the grant made by the royal charter aforesaid, an assembly of the province and three lower counties (then called the territories) was called by the proprietary and governor aforesaid, which met at Chester on the seventh day of December, 1682, when the following laws, among others, were passed, to wit:

> * * * Since * * * it has pleased King Charles the Second * * * to grant * * * William Penn, esq., * * * this Province of Pennsylvania * * * And * James Duke of York and Albany * * * to release his right and claim * * * to the Province of Pennsylvania * * * and * * * to grant unto the said William Penn * * * all that tract of land from twelve miles northward of New Castle, on the river Delaware, down to the South Cape (commonly called Cape Henlopen, and by the Proprietary and Governor now called Cape Jomus) lying on the west side of the said river and bay, * * * lately cast into three counties, called New Castle, Jones, and Whorekills (alias New Dale. * * * Be it enacted * * that the counties of New Castle, Jones, and Whorekills alias New Dale * * * are annexed to the Province of Pennsylvania. * * * (Dallas' Laws of Pennsylvania, 1797, Vol. I, Appendix, p. 24, *et seq*).

In 1701 William Penn granted a charter, under which the province of Pennsylvania and the territories (as Delaware was then called) were made separate governments, though both were still under the proprietary government of William Penn. (C. & C., p. 270.)

By the Revolution the "territories" became the State of Delaware, with substantially her present boundaries.

(For a history of the boundaries between Delaware and Pennsylvania, *vide* Pennsylvania, p. 85, and between Delaware and New Jersey, *vide* New Jersey, p. 83, *et seq.*)

From 1732 to 1769 there was a controversy between the proprietors of Pennsylvania and Maryland in regard to boundaries (*vide* p. 85). The boundaries of Delaware on the north and west—Delaware then being under the jurisdiction of Pennsylvania—were determined as follows, viz:

Beginning at Cape Henlopen and running due west 34 miles 309 perches; thence in a straight line 81 miles 78 chains and 30 links up the peninsula until it touches and makes a tangent to the western periphery of a circle, drawn at the horizontal distance of twelve English statute miles from the center of the town of New Castle.

From this tangent point a line was run due north till it cut a parallel of latitude 15 miles due south of the most southern part of the city of Philadelphia. This point of intersection is the northeast corner of Maryland. The tangent line bearing a little west of north, the due north line from the tangent point cuts off an arc of the 12-mile circle. The boundary line follows the arc of the circle from the tangent point around to the point where the due north line intersects the 12-mile circle, then follows said due north line to said northeast corner of Maryland. The length of said due north line is 5 miles 1 chain and 50 links, as given by Mason and Dixon. (*Vide* Jour. Del. Sen., 1851, p. 56 *et seq.*)

By the agreement of 1760, based on the decree of Chancellor Hardwick, a due east and west line should be run across the peninsula from Cape Henlopen to Chesapeake Bay, etc. The decree of Lord Hardwick says, touching the position of Cape Henlopen, "that Cape Henlopen ought to be deemed and taken to be situated at the place where the same is laid down and described in the map or plan annexed to the said articles to be situated, and therefore his lordship doth further order and decree that the said articles be carried into execution accordingly," etc.

In Hazard's Annals of Pennsylvania, p. 5, is found the following, viz: "The cape now called Henlopen was then called Cornelis."

William Penn directed that Cape Henlopen be called Cape James. (*Vide* Hazard's Pennnsylvania, p. 606; also *vide* Act of union of the territories to Pennsylvania.)

The foregoing statements explain the seeming incongruity between the base line across the peninsula and the position of Cape Henlopen as laid down on all modern maps.

MARYLAND.

The territory comprising the present area of Maryland was included in the previous charters of Virginia, notwithstanding which, in the year 1632, Lord Baltimore received a royal grant of the province of Maryland, whose boundaries are defined in the following extract:

> All that part of the Peninsula or Chersonese, lying in parts of America, between the ocean on the east and the Bay of Chesapeake on the west; divided from the residue thereof by a right line drawn from the promontory or headland called Watkins Point, situate upon the bay aforesaid, near the River Wighco on the west unto the main ocean on the east, and between that boundary on the south unto that part of the Bay of Delaware on the north, which lieth under the fortieth degree of north latitude from the equinoctial, where New England is terminated; and all the tract of that land within the metes underwritten (that is to say), passing from the said bay, called Delaware Bay, in a right line, by the degree aforesaid, unto the true meridian of the first fountain of the River Pattowmack; thence verging towards the south unto the farther bank of the said river, and following the same on the west and south unto a certain place called Cinquack, situate near the mouth of said river, where it disembogues into the aforesaid Bay of Chesapeake, and thence by the shortest line unto the aforesaid promontory or place called Watkins Point, so that the whole tract of land divided by the line aforesaid, between the main ocean and Watkins Point unto the promontory called Cape Charles, may entirely remain forever excepted to us * * * * * *.

By an examination of the limits laid down in this charter, and a comparison with the several charters of Virginia and the charter and deeds to William Penn, it will be seen that there was a conflict of boundaries on both sides of the Maryland grant.

The history of the long controversy with Pennsylvania has already been given (*vide* Pennsylvania, p. 85, and Delaware, p. 87). Virginia on the south claimed the territory under her charters, and for a time seemed disposed to assert her claim, notwithstanding we find in 1638 a proclamation by the governor and council of Virginia recognizing the province of Maryland, and forbidding trade with the Indians within the limits of Maryland without the consent of Lord Baltimore previously obtained (*vide* Bozman's Maryland, vol. II, p. 586). Virginia's claim was finally given up by a treaty or agreement made in 1658. (For a full account *vide* Bozman's Maryland, p. 444 *et seq.*)

In 1663 the Virginia assembly ordered a survey of the line between Virginia and Maryland on the peninsula, and declared it to be as follows, viz:

> From Watkins Point east across the peninsula.

They define Watkins Point

> To be the north side of Wicomicoe River on the Eastern shore and neere unto and on the south side of the streight limbe opposite to Patuxent River.

(*Vide* Hening's Virginia, vol. II, p. 184.)

In 1668 commissioners were appointed by Maryland and Virginia to fix the boundary across the peninsula. The commissioners were Philip Calvert, esq., chancellor of Maryland, and Col. Edmund Scarbrugh, his majesty's surveyor-general of Virginia. Their report is as follows, viz:

> * * * After a full and perfect view taken of the point of land made by the north side of Pocomoke Bay and south side of Annamessexs Bay have and do conclude the same to be Watkins Point, from which said point so called, we have run an east line, agreeable with the extreamest part of the westermost angle of the said Watkins Point, over Pocomoke River to the land near Robert Holston's, and there have marked certain trees which are so continued by an east line running over Swansecutes Creeke into the marsh of the seaside with apparent marks and boundaries * * * Signed June 25, 1868. (*Vide* Md. Hist. Soc. Coll. of State papers, volume marked 4 L. C. B., pp. 63–64.)

Virginia, by the adoption of her constitution of 1776 (see Article 21), relinquished all claim to territory covered by the charter of Maryland, thereby fixing Maryland's western boundary as follows:

> Commencing on a true meridian of the first fountain of the river Pattawmack, thence verging towards the south unto the further bank of the said river and following the same on the west and south unto a certain place called Cinquack, situate near the mouth of said river where it disembogues into the aforesaid bay of Chessopeake, and thence by the shortest line unto the aforesaid promontory or place called Watkins Point, thence a right line to the main ocean on the east. (See charter of Maryland.)

The foregoing are substantially the present boundaries; but from that time up to the present a controversy has been going on concerning them.

In 1786 a compact was entered into between the States of Maryland and Virginia, but as this referred more particularly to the navigation and exercise of jurisdiction on the waters of Chesapeake Bay, the Potomac and Pocomoke Rivers, they are not given here. (*Vide* Hening's Va., Vol. XII, p. 50.)

From 1821 to 1858 frequent legislation took place in regard to this boundary.

In the last-named year commissioners were appointed by Maryland and Virginia, respectively, who, with the assistance of Lieut. N. Michler, United States Engineers, surveyed the lines.

In 1860 the governor of Virginia, under a resolution of the legislature, appointed and sent an agent to England to collect records and documentary evidence bearing on this question.

The rebellion ensuing, nothing further was done until 1867, when legislation again commenced.

The question of this boundary was referred to arbitrators by an agreement made in 1874, each State binding itself to accept their award as final and conclusive.

J. S. Black, of Pennsylvania; William A. Graham, of North Carolina, and Charles A. Jenkins, of Georgia, were appointed arbitrators.

William A. Graham having died, James B. Beck, of Kentucky, was appointed in his stead.

The arbitrators made, in 1877, the following award, viz:

> Beginning at the point on the Potomac River where the line between Virginia and West Virginia strikes the said river at low-water mark, and thence following the meanderings of said river by the low-water mark to Smith's Point, at or near the mouth of the Potomac, in the latitude 37° 53′ 8″ and longitude 76° 13′ 46″; thence crossing the waters of the Chesapeake Bay, by a line running north 65° 30′ east, about nine and a half nautical miles to a point on the western shore of Smith's Island at the north end of Sassafras Hammock, in latitude 37° 57′ 13″, longitude 76° 2′ 52″; thence across Smith's Island south 88° 30′ east five thousand six hundred and twenty yards to the center of Horse Hammock, on the eastern shore of Smith's Island, in latitude 37° 57′ 8″, longitude 75° 59′ 20″; thence south 79° 30′ east four thousand eight hundred and eighty yards to a point marked "A" on the accompanying map, in the middle of Tangier Sound, in latitude 37° 56′ 42″, longitude 75° 56′ 23″, said point bearing from James Island light south 54° west, and distant from that light three thousand five hundred and sixty yards; thence south 10° 30′ west four thousand seven hundred and forty yards by a line dividing the waters of Tangier Sound, to a point where it intersects the straight line from Smith's Point to Watkins Point, said point of intersection being in latitude 37° 54′ 21″, longitude 75° 56′ 55″, bearing from James Island light south 29° west and from Horse Hammock south 34° 30′ east. This point of intersection is marked "B" on the accompanying map. Thence north 85° 15′ east six thousand seven hundred and twenty yards along the line above mentioned, which runs from Smith's Point to Watkins Point until it reaches the latter spot, namely Watkins Point, which is in latitude 37° 54′ 38″, longitude 75° 52′ 44″. From Watkins Point the boundary line runs due east seven thousand eight hundred and eighty yards to a point where it meets a line running through the middle of Pocomoke Sound, which is marked "C" on the accompanying map, and is in latitude 37° 54′ 38″, longitude 75° 47′ 50″; thence by a line dividing the waters of Pocomoke Sound north 47° 30′ east five thousand two hundred and twenty yards to a point in said sound marked "D" on the accompanying map, in latitude 37° 56′ 25″, longitude 75° 45′ 26″; thence following the middle

of Pocomoke River by a line of irregular curves, as laid down on the accompanying map, until it intersects the westward protraction of the boundary line marked by Scarborough and Calvert, May 28, 1668, at a point in the middle of Pocomoke River, and in the latitude 37° 59′ 37″, longitude 75° 37′ 4″; thence by the Scarborough and Calvert line, which runs 5° 15′ north of east, to the Atlantic Ocean.

The latitudes, longitudes, courses, and distances here given have been measured upon the Coast Chart No. 33 of U. S. Coast Survey, sheet No. 3, Chesapeake Bay. * * * The middle thread of the Pocomoke River and the low-water mark on the Potomac River are to be measured from headland to headland, without considering or following arms, inlets, creeks, bays, or affluent rivers. * * * (*Vide* U. S. Stat. at Large, Vol. XX, p. 481.)

This award was ratified by the States of Maryland and Virginia, and confirmed by Congress in 1879.

In 1879–'80 acts were passed by the legislatures of Maryland and Virginia to appoint commissioners and to request the General Government to designate one or more officers of the Engineer Corps, said commissioners and officers to survey and mark said line and erect monuments thereon.

West Virginia having been formed from a part of Virginia and admitted into the Union in 1862, the western boundary of Maryland now separates it from the State of West Virginia.

The commissioners appointed in 1859 by Virginia and Maryland (*vide* p. 90) surveyed the western boundary from the "Fairfax Stone" (the first fountain of the Potomac) due north to the Pennsylvania line, and the legislature of Maryland in 1860 passed an act declaring that line to to be its western boundary.

From the "Fairfax Stone" the boundary between Maryland and West Virginia runs along the south bank of the Potomac River till it strikes the line between Virginia and West Virginia.

(For a history of the placing of the Fairfax Stone, *vide* Virginia, p. 96.)

DISTRICT OF COLUMBIA.

On the 5th day of September, 1774, the Continental Congress met at Philadelphia. Two years later they adjourned to Baltimore. During the Revolution and subsequent to the treaty of peace they met in various places. After the close of the war much debate took place in regard to the location of a permanent seat of the Government of the United States. Several States made propositions to Congress, offering to cede certain lands for the purpose, but no determination of the location was made by Congress until 1790.

Act of cession from the State of Maryland, passed December 23, 1788.

On the 23d of December, 1788, the State of Maryland passed the following act, viz:

Be it enacted by the general assembly of Maryland, That the representatives of

State in the House of Representatives of the Congress of the United States, appointe to assemble at New York, on the first Wednesday of March next, be and they a hereby authorized and required on the behalf of this State to cede to the Congress the United States, any district in this State not exceeding ten miles square, which t Congress may fix upon and accept for the seat of government of the United States.

In the following year (December 3, 1789), the State of Virginia passe a similar act, of which the following is an extract:

Be it therefore enacted by the general assembly, That a tract of country not exceedin ten miles square or any lesser quantity, to be located within the limits of the Stat and in any part thereof as Congress may by law direct shall be, and the same is hereby forever ceded and relinquished to the Congress and Government of the United State in full and absolute right and exclusive jurisdiction, as well of said soil as of perso residing or to reside thereon, pursuant to the tenor and effect of the eighth sectio of the 1st article of the Constitution of the Government of the United States.

After long discussion, Congress in 1790, in view of the foregoing ce sions of Maryland and Virginia, passed the following act, viz:

AN ACT for establishing the temporary and permanent seat of government of the United Stat
Approved July 16, 1790.

SECT. 1. *Be it enacted by the Senate and House of Representatives of the United States America in Congress assembled*, That a district of territory, not exceeding ten mil square, to be located as hereafter directed on the river Potowmac, at some place b tween the mouth of the Eastern Branch and Connoyocheque, be, and the same i hereby, accepted for the permanent seat of the government of the United State *Provided nevertheless*, That the operation of the laws of the State within such distric shall not be affected by this acceptance until the time fixed for the removal of the go ernment thereto, and until Congress shall otherwise by law provide.

SECT. 2. *And be it further enacted*, That the President of the United States be autho ized to appoint, and by supplying vacancies happening from refusals to act or othe causes, to keep in appointment as long as may be necessary, three commissioner who, or any two of whom, shall, under the direction of the President, survey, and b proper metes and bounds define and limit, a district of territory, under the limitation above mentioned; and the district so defined, limited, and located shall be deeme the district accepted by this act for the permanent seat of the government of th United States.

SECT. 3. *And be it enacted*, That the said commissioners, or any two of them, shal have power to purchase or accept such quantity of land on the eastern side of the sai river within the said district as the President shall deem proper for the use of th United States, and according to such plans as the President shall approve. The sai commissioners, or any two of them, shall, prior to the first Monday in December i the year 1800, provide suitable buildings for the accommodation of Congress, and o the President, and for the public offices of the government of the United States.

SECT. 4. *And be it enacted*, That for defraying the expenses of such purchases an buildings the President of the United States be authorized and requested to accep grants of money.

SECT. 5. *And be it enacted*, That prior to the first Monday in December next all office attached to the seat of government of the United States shall be removed to, an until the first Monday in December in the year 1800 shall remain at, the city of Phil delphia, in the State of Pennsylvania, at which place the session of Congress nex ensuing the present shall be held.

SECT. 6. *And be it enacted*, That on the first Monday in December, in the year 180 the seat of the government of the United States, shall, by virtue of this act, be tran ferred to the district and place aforesaid. And all offices attached to the said seat government shall accordingly be removed thereto by their respective holders, an shall, after the said day, cease to be exercised elsewhere, and that the necessary expense of said removal, shall be defrayed out of the duties on imposts and tonnage, of which a sufficient sum is hereby appropriated.

In the following year the foregoing act was amended, in order to include a portion of the Anacostia River ("Eastern Branch"), and the town of Alexandria within the limits of the district.

The following is the act of amendment:

AN ACT to amend "An act for establishing the temporary and permanent seat of government of the United States." Approved March 3, 1791.

Be it enacted, &c., That so much of the act entitled "An act for establishing the temporary and permanent seat of the government of the United States, as requires that the whole of the district of territory, not exceeding ten miles square, to be located on the river Potowmac, for the permanent seat of the government of the United States, shall be located above the mouth of the Eastern Branch, be and is hereby repealed, and that it shall be lawful, for the President to make any part of the territory below said limit and above the mouth of Hunting Creek, a part of the said district so as to include a convenient port of the Eastern Branch, and of the lands lying on the lower side thereof; and also the town of Alexandria, and the territory so to be included shall form a part of the district not exceeding ten miles square for the permanent seat of the government of the United States, in like manner, and to all intents and purposes, as if the same had been within the the purview of the above recited act: *Provided*, That nothing herein contained, shall authorize the erection of the public buildings, otherwise than on the Maryland side of the river Potowmac, as required by the aforesaid act.

In pursuance of the foregoing acts, three commissioners were appointed, who made preliminary surveys of the territory, and on the 30th day of March, 1791, George Washington, President of the United States, issued a proclamation, in which the bounds of the said District were defined as follows, viz:

Beginning at Jones' Point, being the upper cape of Hunting Creek, in Virginia, and at an angle in the outset of 45° west of the north, and running in a direct line ten miles for the first line; then beginning again at the same Jones' Point and running another direct line at a right angle with the first, across the Potomac, ten miles for the second line; then, from the terminations of the said first and second lines, running two other direct lines, of ten miles each, the one crossing the Potomac and the other the Eastern Branch aforesaid, and meeting each other in a point.

In 1800 Congress removed to this District. In the following year the District was divided into two counties, as follows, viz:

UNITED STATES STATUTES AT LARGE, SIXTH CONGRESS, SECOND SESSION, 1801, (CHAPTER XV).

AN ACT concerning the District of Columbia.

The said District of Columbia shall be formed into two counties. One county shall contain all that part of said District which lies on the east side of the river Potomac, together with the islands therein, and shall be called the county of Washington, the other county shall contain all that part of said District which lies on the west side of said river, and shall be called the county of Alexandria; and the said river, in its whole course through said District, shall be taken and deemed to all intents and purposes to be within both of said counties.

In 1846 Congress passed an act retroceding to the State of Virgi that part of the District of Columbia originally ceded to the Unit States by Virginia. The following is an extract from said act of ret cession:

> That with assent of the people of the county and town of Alexandria, to be asc tained as hereinafter prescribed, all of that portion of the District of Columbia ce to the United States by the State of Virginia, and all the rights and jurisdict therewith ceded over the same, be, and the same are, hereby ceded and forever linquished to the State of Virginia in full and absolute right and jurisdiction, as w of soil as of persons residing or to reside thereon.

VIRGINIA.

In the year 1606 King James I of England granted the "First Ch ter of Virginia." The boundaries therein described are as follows, v

> * * * Situate, lying, or being all along the sea coasts, between four and thi degrees of northerly latitude from the equinoctial line, and five and forty degree the same latitude, and in the main land between the same four and thirty and f and forty degrees and the islands thereunto adjacent, or within one hundred mile the coast thereof. * * *

Soon after, in 1609, a new charter was granted, called the "Seco Charter of Virginia," which defines the boundaries in the followi terms:

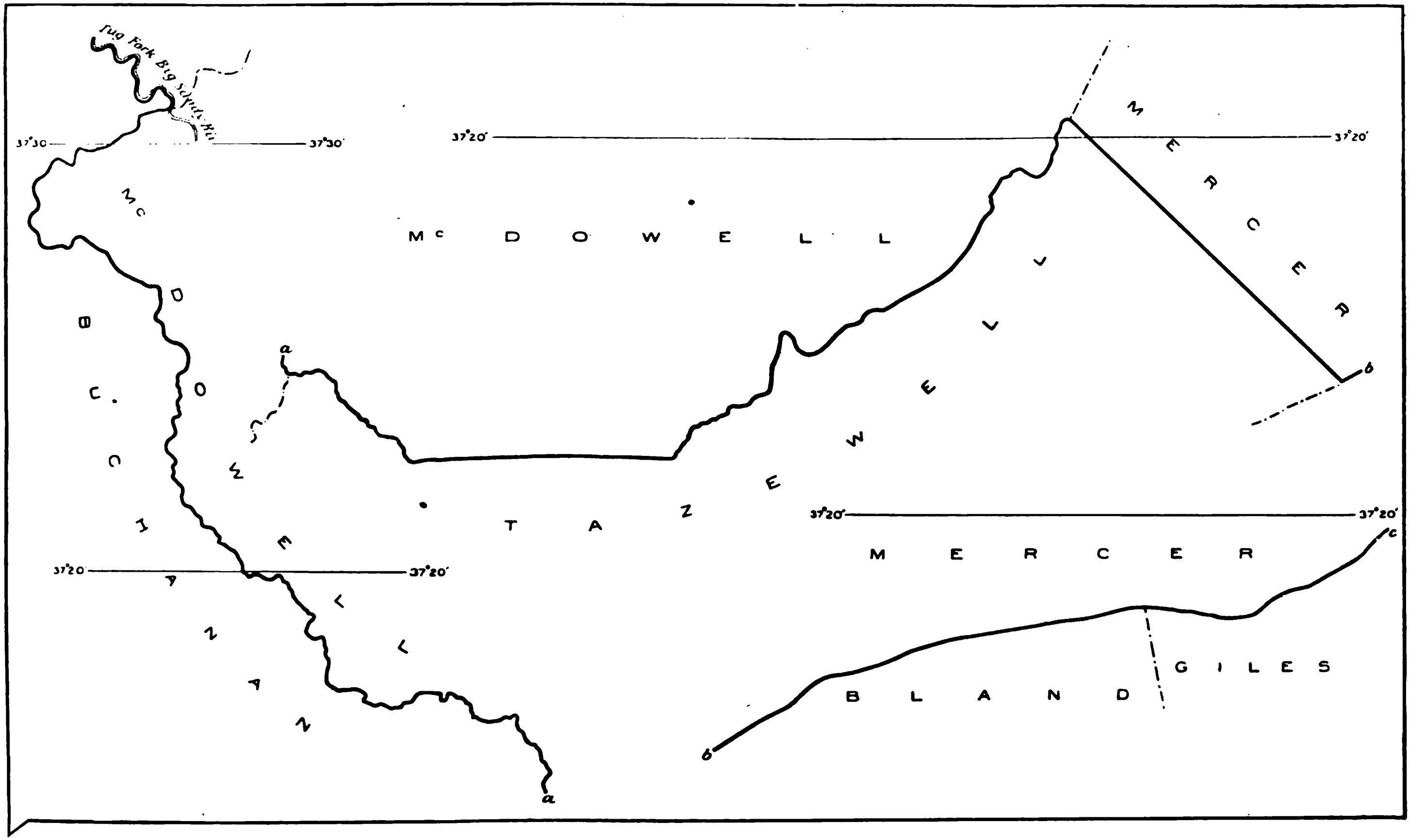
> * * * Situate, lying, and being in that part of America called Virginia, fr the point of land called Cape or Point Comfort, all along the sea coast to the no ward two hundred miles, and from the said point of Cape Comfort all along the coast to the southward two hundred miles, and all that space and circuit of l lying from the sea coast of the precinct aforesaid up into the land, throughout fr sea to sea, west and northwest, and also all the islands lying within one hund miles along the coast of both seas of the precinct aforesaid. * * *

In 1611-'12 the "Third Charter of Virginia" was granted, which w an enlargement of the second, of which the following is an extract:

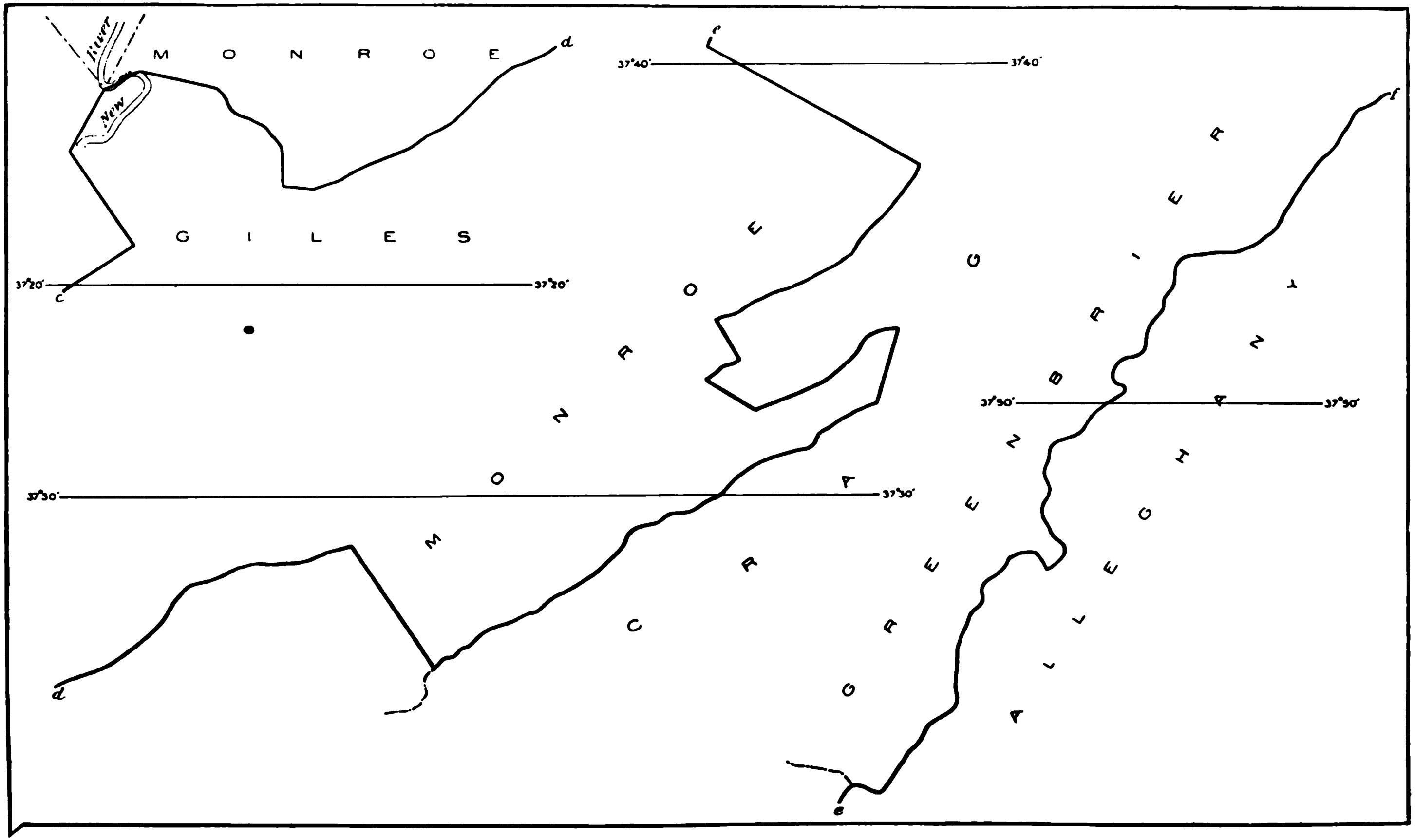
> All and singular those islands whatsoever, situate and being in any part of the co seas bordering upon the coast of our said first colony in Virginia, and being wit three hundred leagues of any of the portes heretofore granted to the said treas and company in our former letters-patents as aforesaid, and being within or betw the one-and-fortieth and thirtieth degrees of northerly latitude.

These boundaries, as will be seen, included territory composing whol or in part, the present States of Pennsylvania, Delaware, Maryla North and South Carolina, in addition to others formed since the Re lution.

This large extent of territory was reduced in the first instance by t charter of Maryland in 1632, next by the charters of Carolina in 16 and 1665, then by the charter of Pennsylvania in 1681, and, again, su sequent to the Revolution, by the cession to the United States of t territory northwest of the Ohio River in 1784; by the admission



BOUNDARY BETWEEN VIRGINIA AND WEST VIRGINIA.



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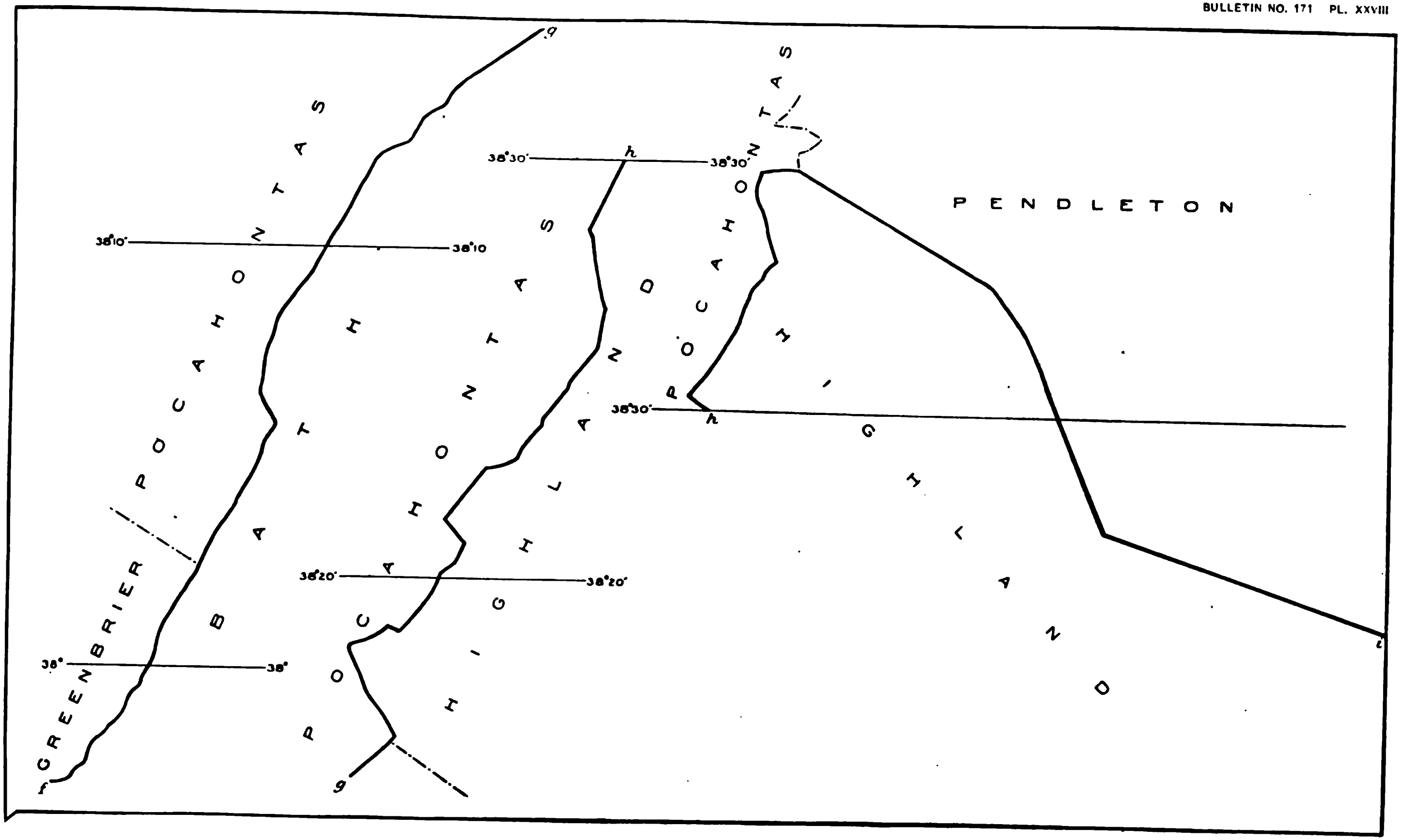
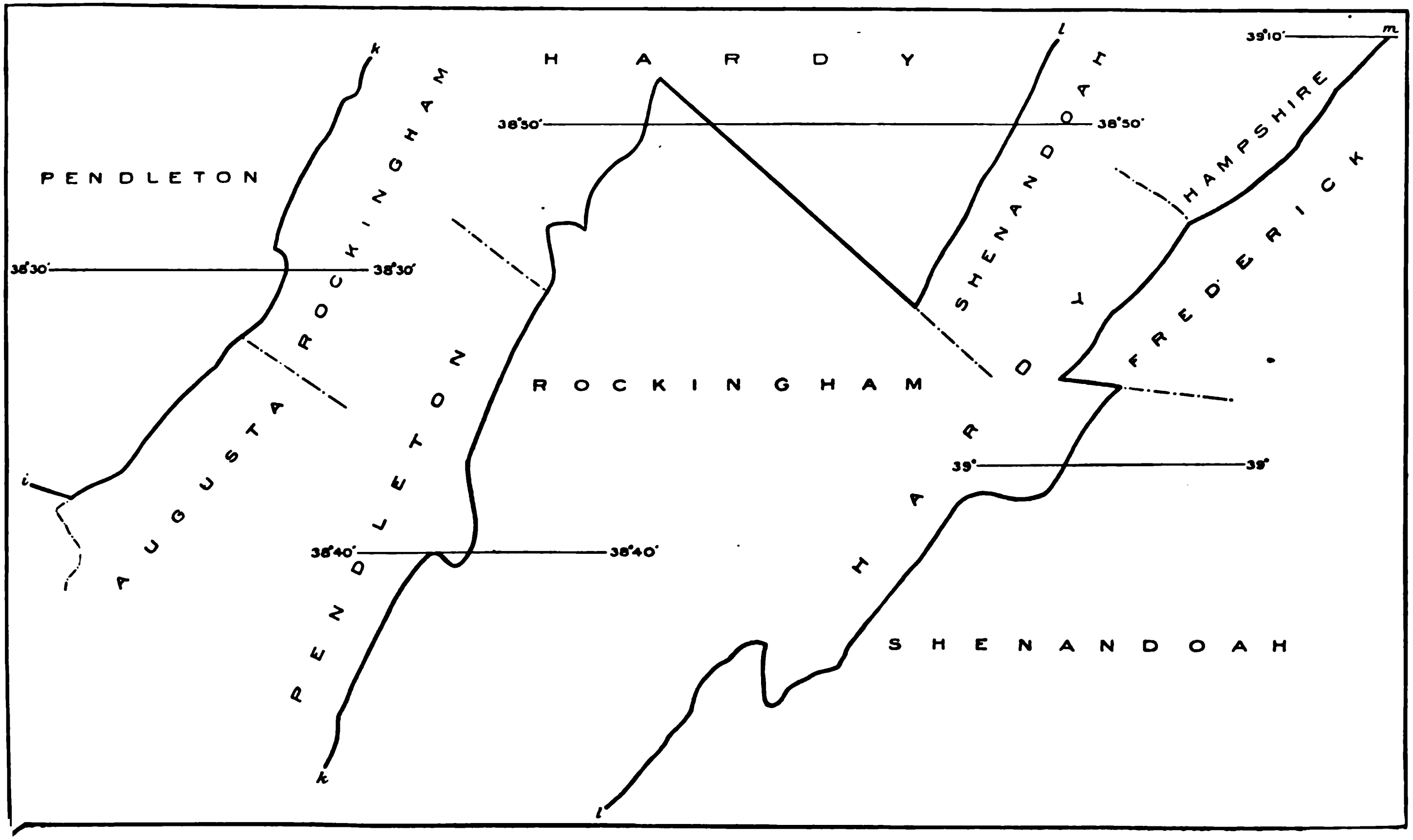


BOUNDARY BETWEEN VIRGINIA AND WEST VIRGINIA.



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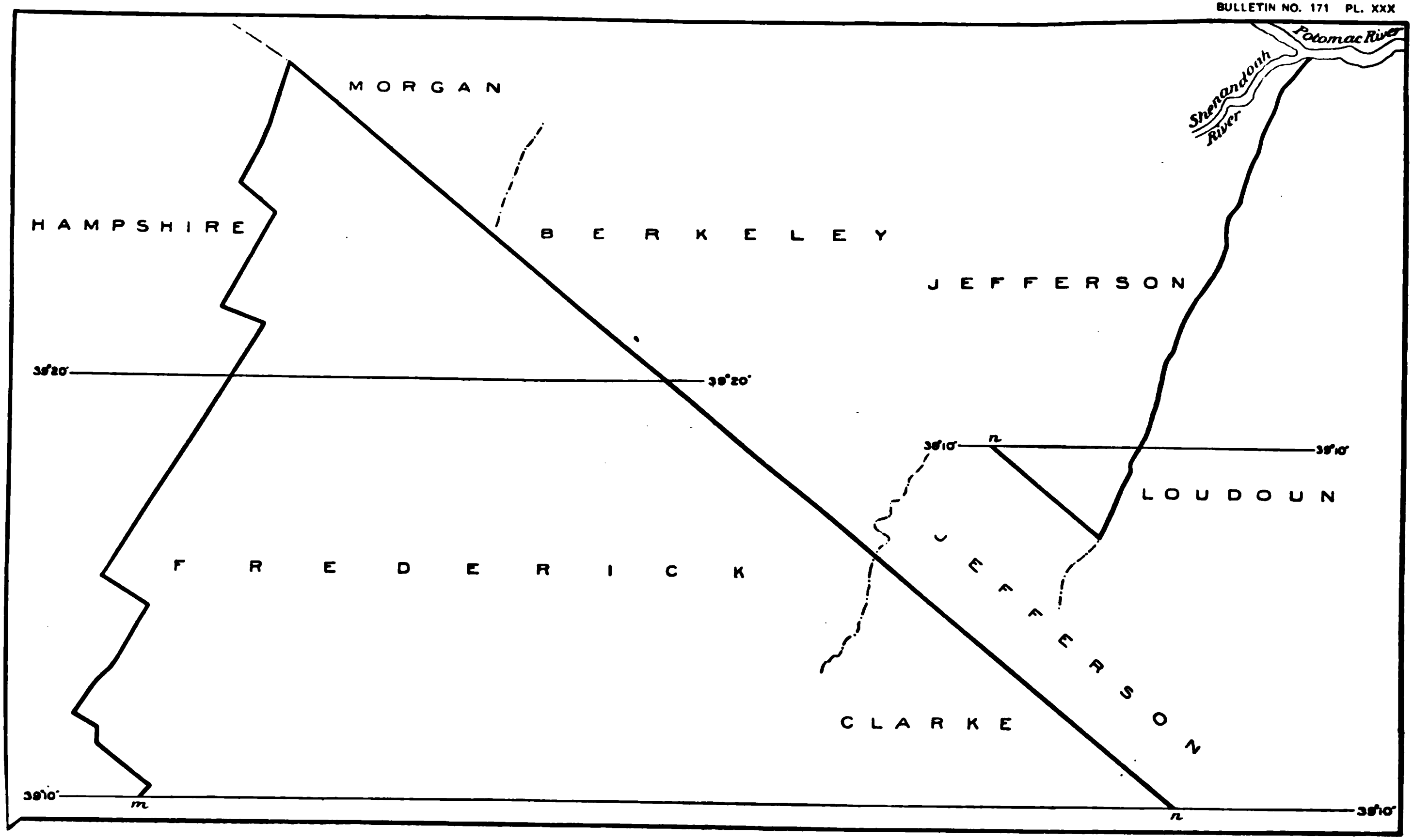


BOUNDARY BETWEEN VIRGINIA AND WEST VIRGINIA.

Kentucky as an independent State in 1792, and lastly by the division of the territory of Virginia in 1862, by which the new State of West Virginia was created and admitted into the Union.

By the constitution of 1776 Virginia formally gave up all claim to the territory now appertaining to the neighboring States of Maryland, Pennsylvania, North and South Carolina.

The following is an extract from the Virginia constitution of 1776:

> The territories contained within the charters erecting the colonies of Maryland, Pennsylvania, North and South Carolina, are hereby ceded, released, and forever confirmed to the people of these colonies, respectively, with all the rights of property, jurisdiction, and government, and all the rights whatsoever, which might at any time heretofore have been claimed by Virginia, except the free navigation and use of the rivers Potomaque and Pokomoke, with the property of the Virginia shores and strands bordering on either of said rivers, and all improvements which have been or shall be made thereon. The western and northern extent of Virginia shall, in all other respects, stand as fixed by the charter of King James I, in the year one thousand six hundred and nine, and by the public treaty of peace between the courts of Britain and France in the year one thousand seven hundred and sixty-three, unless by act of the legislature one or more governments be established westwards of the Alleghany Mountains.

In the mean time a grant of territory had been made, within the present limits of Virginia and West Virginia, which caused great dissatisfaction to the people of the Virginia Colony, and which ultimately had an important bearing in settling the divisional line between Maryland and Virginia.

In the 21st year of Charles II a grant was made to Lord Hapton and others of what is called the northern neck of Virginia, which was sold by the other patentees to Lord Culpeper and confirmed to him by letters-patent in the fourth year of James II. This grant carried with it nothing but the right of soil and incidents of ownership, it being expressly subjected to the jurisdiction of the government of Virginia. The tract of land thereby granted was "bounded by and within the heads of the rivers Tappahannock, alias Rappahannock, and Quiriough, alias Patomac, rivers." On the death of Lord Culpeper, this proprietary tract descended to Lord Fairfax, who had married Lord Culpeper's only daughter.

As early as 1729 difficulties sprung up, arising from conflicting grants from Lord Fairfax and the Crown.

In 1730 Virginia petitioned the King, reciting that the head springs of the Rappahannock and Potomac Rivers were not known, and praying that such measures might be taken that they might be ascertained to the satisfaction of all parties.

In 1733 Lord Fairfax made a similar petition, asking that a commission might issue for running out, marking, and ascertaining the true boundaries of his grant.

An order, accordingly, was issued and three commissioners were appointed on the part of the Crown and three on the part of Lord Fairfax.

The duty which devolved upon these commissioners was to ascertai by actual examination and survey the respective fountains of the Rappahannock and Potomac Rivers. This survey was made in 1736.

The report of the commissioners was referred to the council for plantation affairs in 1738, who reported their decision in 1745, as follows viz:

> * * * The said boundary ought to begin at the first spring of the south branc of the river Rappahannock, and that the said boundary be from thence drawn in straight line northwest to the place in the Alleghany Mountains where that part o the Potomac River, which is now called Cohongoroota, first rises. * * *

This report was confirmed by the King, and commissioners were appointed to run and mark the dividing line accordingly.

The line was run in 1746. On the 17th day of October, 1746, the planted the Fairfax stone at the spot which had been described an marked by the preceding commissioners as the true head spring of th Potomac River, and which, notwithstanding much controversy, ha continued to be regarded, from that period to the present time, as th southern point of the western boundary between Virginia and Maryland. (*Vide* Faulkner's Report to Governor of Virginia, 1832. For ful details, *vide* Byrd Papers, 1866, Vol. II, p. 83 *et seq.* Also Hening' Va. Statutes.)

This tract of country was held by Lord Fairfax and his descendant many years, but subsequent to the Revolution the quitrents, charges etc., were abolished and it became in all respects subject to the jurisdiction of Virginia.

(For the history of the settlement of the boundary lines between Vi ginia and Maryland, *vide* Maryland, p. 89.)

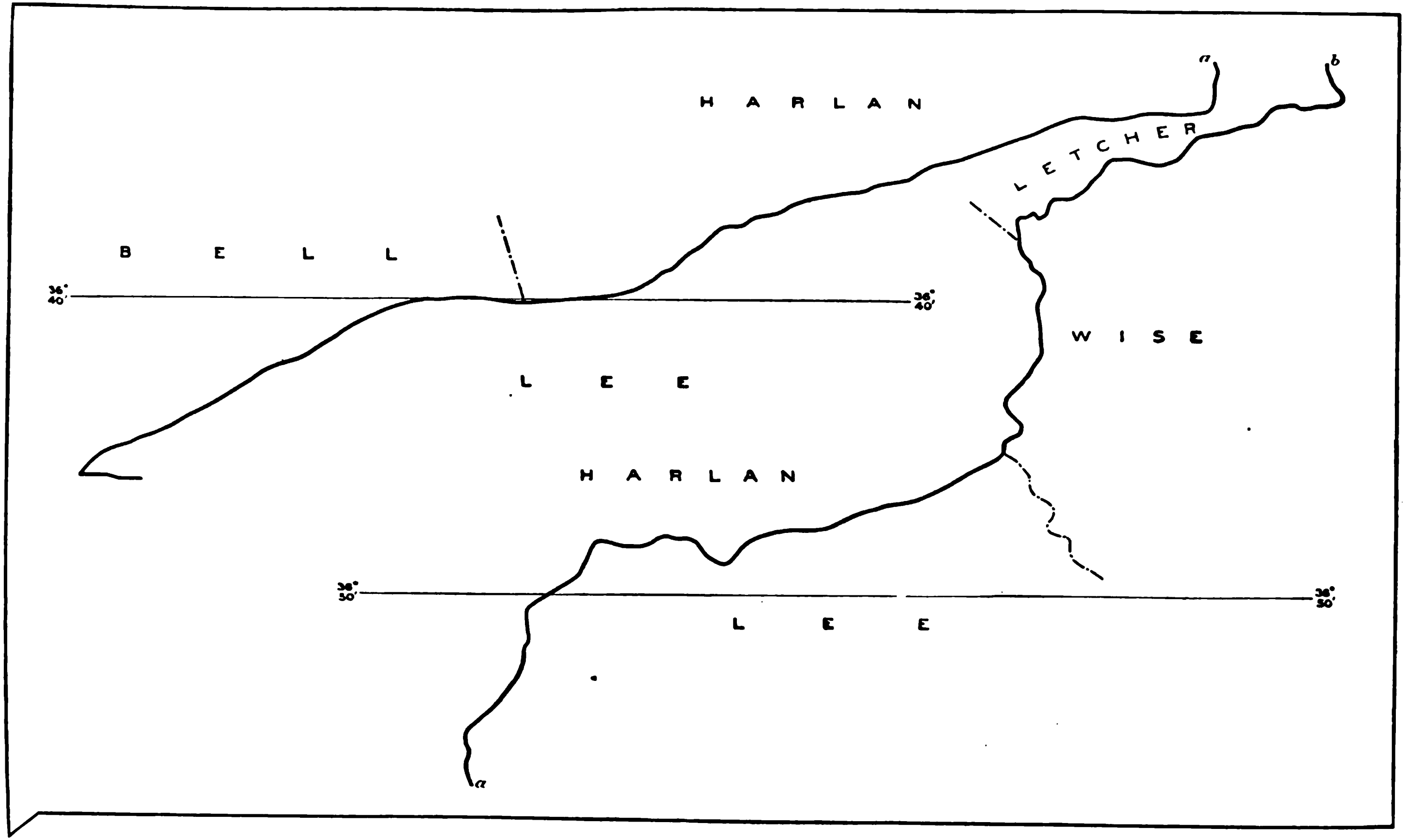
(For a history of the boundary between Virginia and Pennsylvania *vide* Pennsylvania, p. 87.)

Kentucky formed originally a part of the county of Fincastle, Vi ginia. In the year 1776, this county was divided into three countie the westernmost of which was called Kentucky County, and its easter boundary was declared to be as follows, viz:

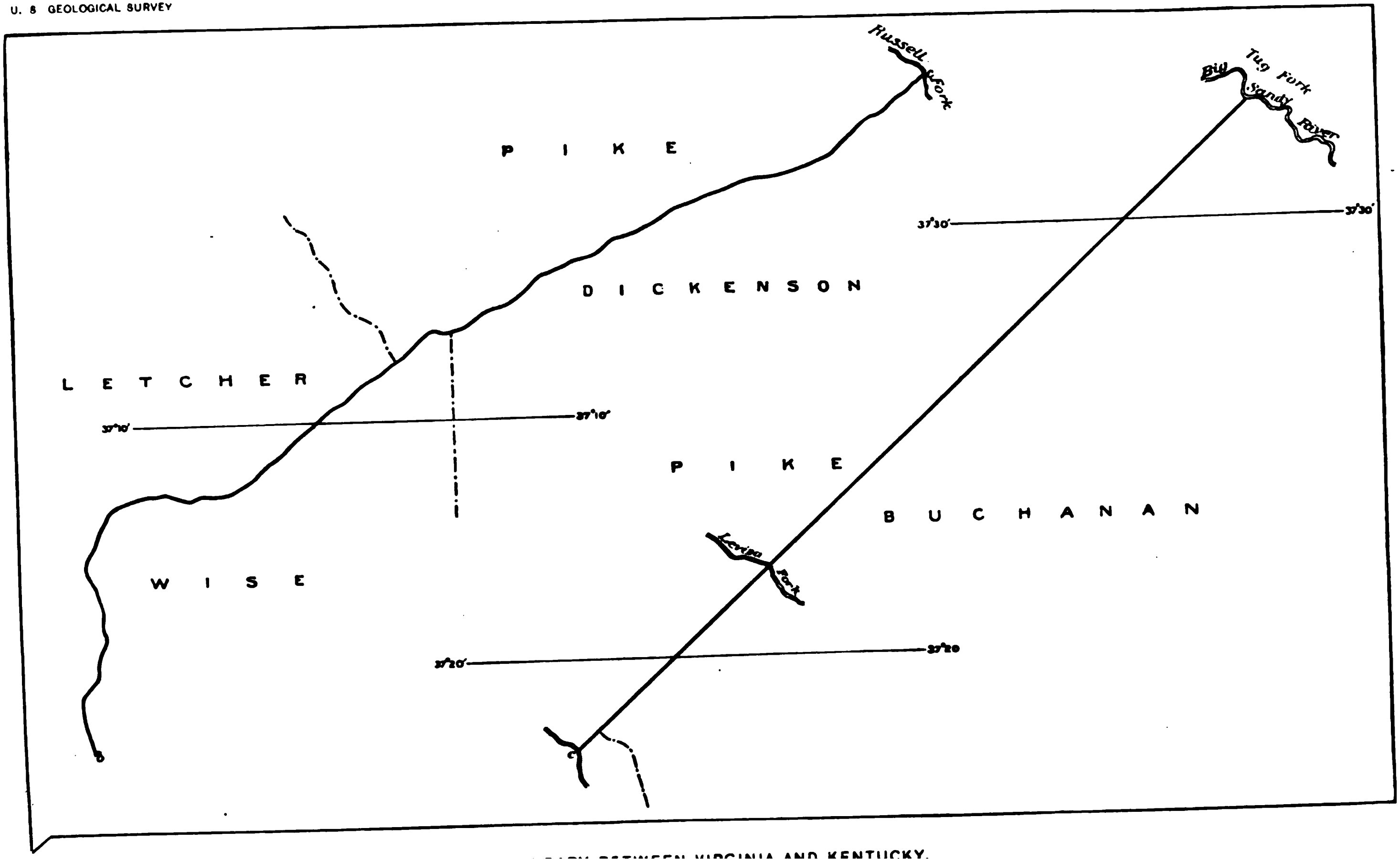
> A line beginning on the Ohio, at the mouth of Great Sandy Creek, and runnin up the same and the main or northeasterly branch thereof to the Great Laurel Ridg or Cumberland Mountains; thence southwesterly along the said mountain to the lin of North Carolina. (See Hening's Statutes, Virginia, Vol. 9, p. 257.)

Kentucky having been admitted into the Union June 1, 1792, commissioners were appointed in 1798 by Virginia and Kentucky to fix th boundary. In 1799–1800 the commissioners' report was made and ratified by the States. It was as follows, viz:

> To begin at the point where the Carolina, now Tennessee, line crosses the top of th Cumberland Mountains, near Cumberland Gap, thence northeastwardly along the to or highest part of the said Cumberland Mountain, keeping between the head wate of Cumberland and Kentucky Rivers, on the west side thereof, and the head wate of Powell's and Guest's Rivers, and the Pond Fork of Sandy, on the east side there continuing along the said top, or highest part of said mountain, crossing the ro



BOUNDARY BETWEEN VIRGINIA AND KENTUCKY.



DARY BETWEEN VIRGINIA AND KENTUCKY.

leading over the same at the Little Paint Gap, where by some it is called the Hollow Mountain and where it terminates at the West Fork of Sandy, commonly called Russell's Fork, thence with a line to be run north 45° east till it intersects the other great principal branch of Sandy, commonly called the Northeastwardly branch, thence down the said Northeastwardly branch to its junction with the main west branch and down Main Sandy to its confluence with the Ohio. (See Shepard's Virginia, Vol. 2, p. 234.)

It will be seen that the latter part of this line is the present line between West Virginia and Kentucky.

(For the history of the settlement of the boundaries between Virginia and North Carolina, *vide* North Carolina, *vide* p. 100.)

In 1779 Virginia and North Carolina appointed commissioners to run the boundary line between the two States west of the Allegheny Mountains, on the parallel of 36° 30′. The commissioners were unable to agree on the location of the parallel; they therefore ran two parallel lines two miles apart, the northern known as Henderson's, and claimed by North Carolina, the southern known as Walker's line, and claimed by Virginia. In the year 1789 North Carolina ceded to the United States all territory west of her present boundaries, and Tennessee being formed from said ceded territory, this question became one between Virginia and Tennessee.

Commissioners having been appointed by Virginia and Tennessee to establish the boundary, their report was adopted in 1803, and was as follows, viz:

> A due west line equally distant from both Walker's and Henderson's, beginning on the summit of the mountain generally known as White Top Mountain, where the northeast corner of Tennessee terminates, to the top of the Cumberland Mountain, where the southwestern corner of Virginia terminates.

In 1871 Virginia passed an act to appoint commissioners to adjust this line.

Tennessee, the following year, in a very emphatic manner, passed a resolution refusing to reopen a question regarding a boundary which she considered "fixed and established beyond dispute forever." (See acts of Tennessee, 1872.)

Up to 1783 Virginia exercised jurisdiction over a large tract of country northwest of the Ohio River. But by a deed executed March 1, 1784, she ceded to the United States all territory lying northwest of the Ohio River, thus making her western boundary the west bank of the Ohio River.

On the 31st of December, 1862, the State of Virginia was divided, and 48 counties, composing the western part of the State, were made the new State of West Virginia. By an act of Congress in 1866, consent was given to the transfer of two additional counties from Virginia to West Virginia.

In 1873 and 1877 commissioners were appointed by each State to determine the true boundaries between the two States, and the General

Government was asked to detail officers of engineers to act with said commissioners in surveying and fixing the line.

Until their report is at hand, the boundary can only be found by following the old county lines. In view of the expectation of such report at an early day, it has not been thought best to go into an examination of the old county lines.

WEST VIRGINIA.

This State was set off from Virginia on December 31, 1862. It was originally formed of those counties of Virginia which had refused to join in the secession movement. It was admitted to the Union as a separate State, June 19, 1863. It originally contained the following counties: Barbour, Boone, Braxton, Brooke, Cabell, Calhoun, Clay, Doddridge, Fayette, Gilmer, Greenbrier, Hampshire, Hancock, Hardy, Harrison, Jackson, Kanawha, Lewis, Logan, Marion, Marshall, Mason, McDowell, Mercer, Monongalia, Monroe, Morgan, Nicholas, Ohio, Pendleton, Pleasants, Pocahontas, Preston, Putnam, Raleigh, Randolph, Ritchie, Roane, Taylor, Tucker, Tyler, Upshur, Wayne, Webster, Wetzel, Wirt, Wood, Wyoming.

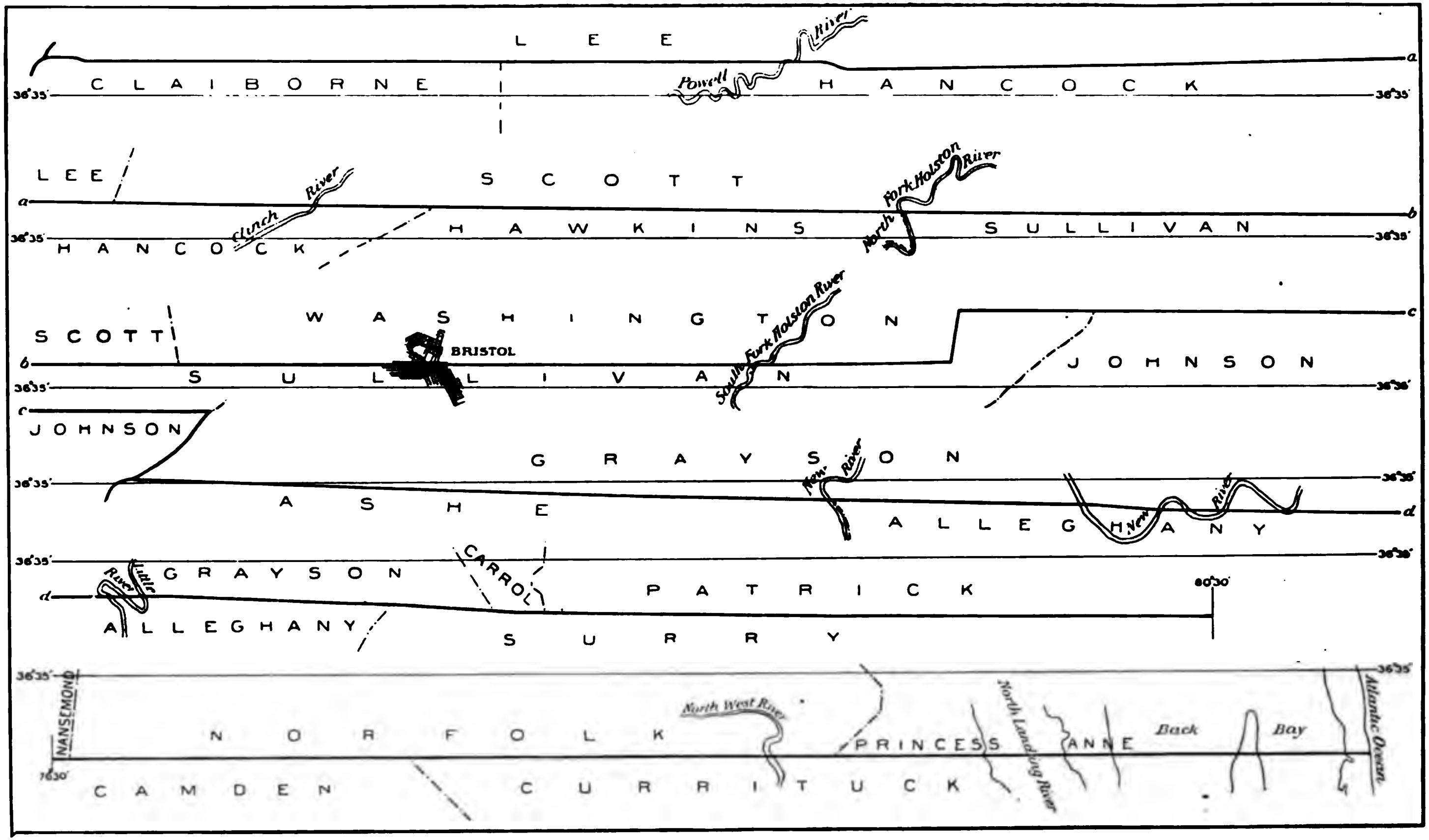
In 1866 it was enlarged by the two counties of Berkeley and Jefferson, transferred from Virginia. Its boundary with Virginia is made up of boundary lines of the border counties above enumerated; and can be defined only by reference to the laws by which these counties were created. In the constitution of 1872, after a recapitulation of the counties which were transferred from Virginia to West Virginia, is found the following clause defining the boundaries upon the south and west:

> The State of West Virginia includes the bed, bank, and shores of the Ohio River, and so much of the Big Sandy River as was formerly included in the Commonwealth of Virginia, and all territorial rights and property in and jurisdiction over the same heretofore reserved by and vested in the Commonwealth of Virginia, are vested in and shall hereafter be exercised by the State of West Virginia; and such parts of the said beds, banks, and shores as lie opposite and adjoining the several counties of this State shall form parts of said several counties respectively.

(For a history of the boundaries of West Virginia, *vide* Pennsylvania, p. 86; Maryland, p. 89; Virginia, p. 95.)

NORTH CAROLINA.

In the year 1663 the "first charter of Carolina" was granted, which, two years later, in 1665, was enlarged by the "second charter of Carolina."



BOUNDARY BETWEEN VIRGINIA, TENNESSEE, AND NORTH CAROLINA.

The following extracts from these two charters define the boundaries:

Charter of Carolina, 1663.

* * * All that territory or tract of ground, scituate, lying and being within our dominions of America, extending from the north end of the island called Lucke Island, which lieth in the Southern Virginia seas, and within six and thirty degrees of the northern latitude, and to the west as far as the south seas, and so southerly as far as the river Saint Matthias, which bordereth on the coast of Florida, and within one and thirty degrees of northern latitude, and so west in a direct line as far as the south seas aforesaid. * * *

Charter of Carolina, 1665.

* * * All that province, territory, or tract of land, scituate, lying or being in our dominions of America, aforesaid, extending north and eastward as far as the north end of Currituck River, or inlet, upon a strait westerly line to Wyonoke Creek, which lies within or about the degrees of thirty-six and thirty minutes, northern latitude, and so west in a direct line as far as the south seas. * * *

This is an extension of the charter of 1663, by which its northern boundary was removed from the approximate latitude of 36° to 36° 30′, on which parallel it is now approximately established. Although the exact year in which the division of the province of Carolina into the two provinces of North and South Carolina appears somewhat uncertain, I find it generally put down as 1729. The division line between the two provinces, North and South Carolina, appears to have been established by mutual agreement.

In the constitution of North Carolina of 1776 this line is defined as shown in the subjoined extract:

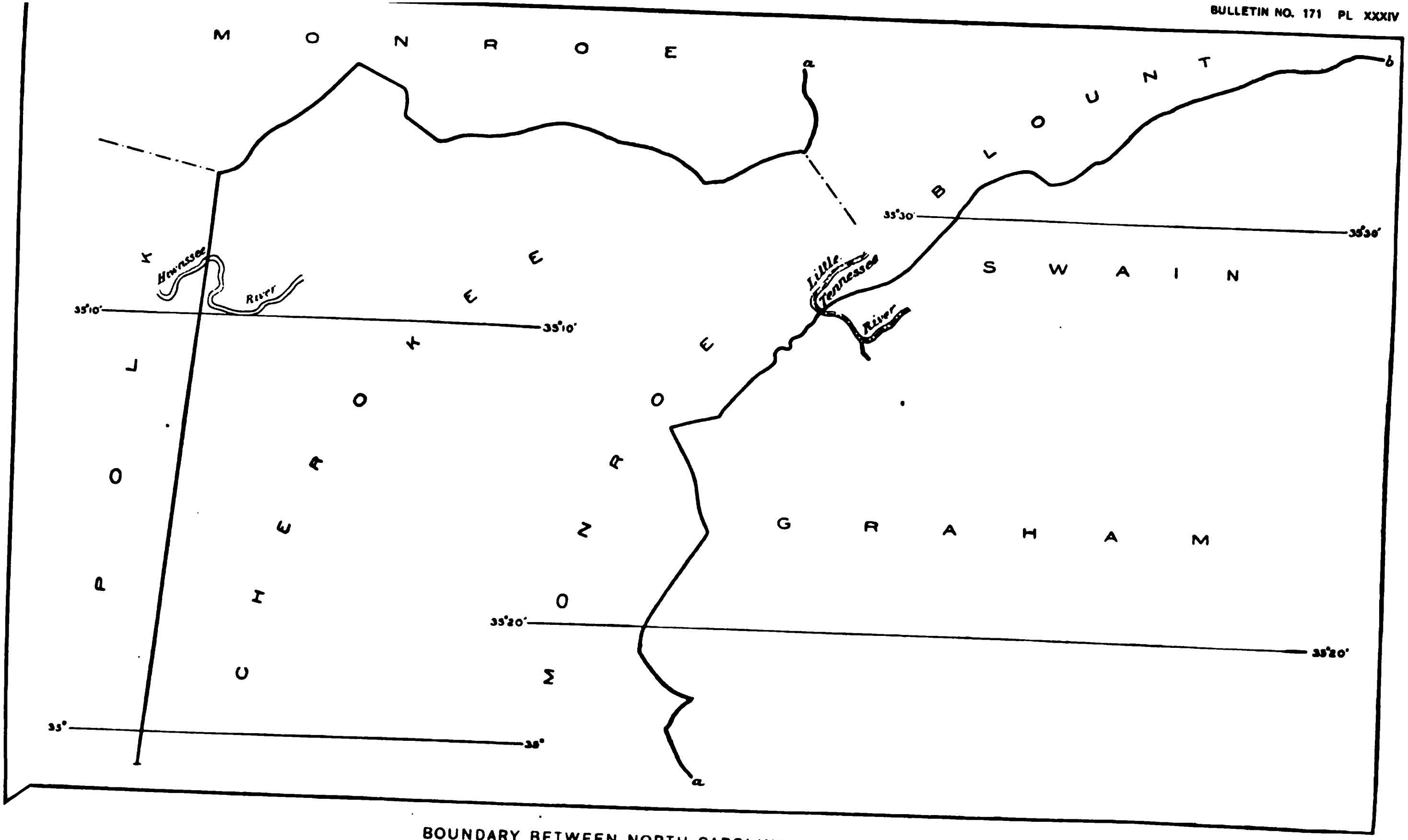
The property of the soil, in a free government, being one of the essential rights of the collective body of the people, it is necessary, in order to avoid future disputes, that the limits of the State should be ascertained with precision; and as the former temporary line between North and South Carolina was confirmed and extended by commissioners appointed by the legislatures of the two States, agreeable to the order of the late King George II in council, that line, and that only, should be esteemed the southern boundary of this State; that is to say, beginning on the sea side at a cedar stake, at or near the mouth of Little River (being the southern extremity of Brunswic County), and running from thence a northwest course through the boundary house, which stands in thirty-three degrees fifty-six minutes, to thirty-five degrees north latitude, and from thence a west course so far as is mentioned in the charter of King Charles II to the late proprietors of Carolina. Therefore, all the territory, seas, waters, and harbours, with their appurtenances, lying between the line above described, and the southern line of the State of Virginia, which begins on the sea shore, in thirty-six degrees thirty minutes north latitude, and from thence runs west, agreeable to the said charter of King Charles, are the right and property of the people of the State, to be held by them in sovereignty, any partial line, without the consent of the legislature of this State, at any time thereafter directed or laid out in anywise notwithstanding.

On December 2, 1789, the legislature passed an act ceding to the United States its western lands, now constituting the State of Tennessee. On February 25, 1790, the deed was offered, and on April 2 of the same year it was accepted by the United States.

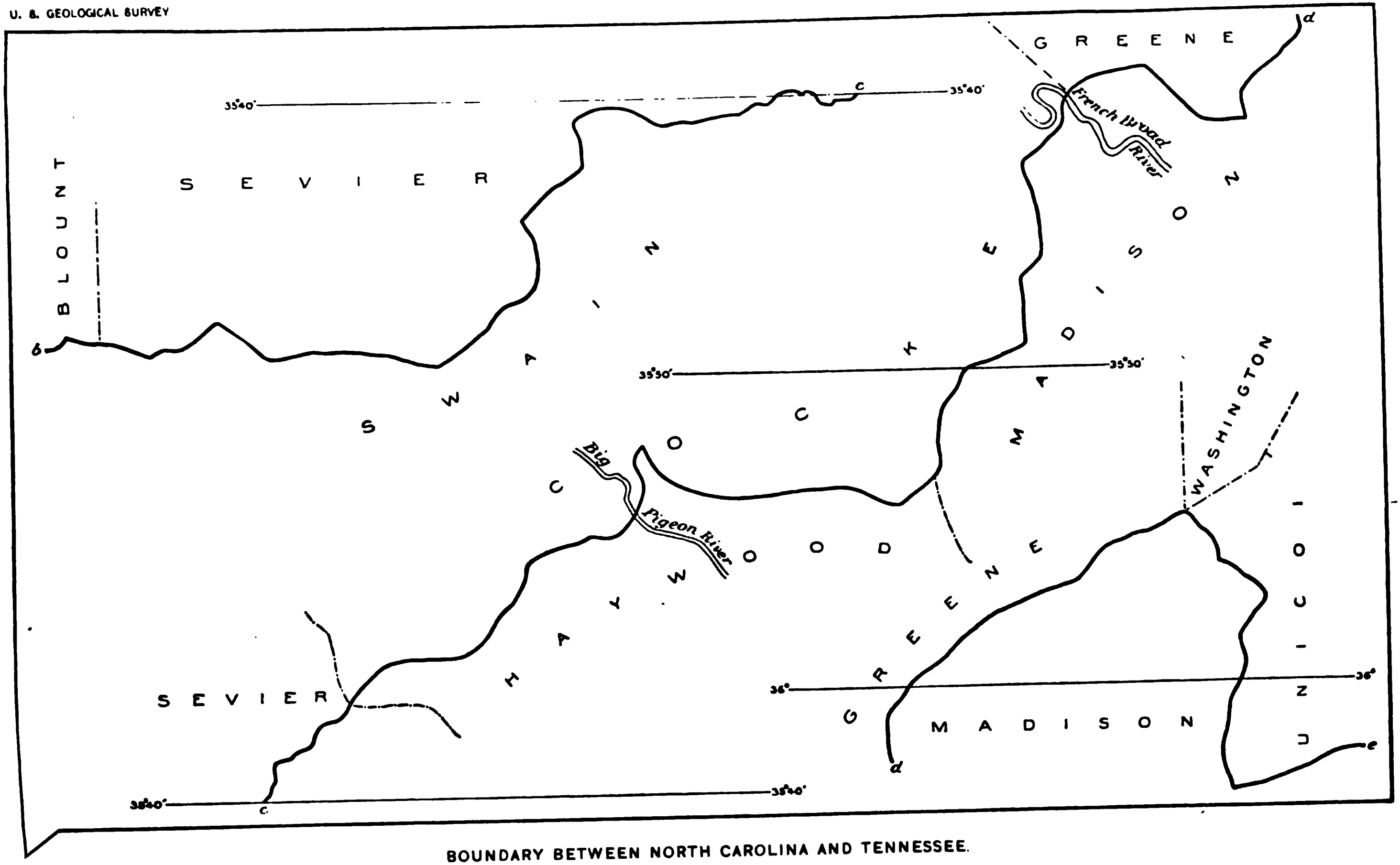
In the Revised Statutes the north and south boundaries of the State are claimed to be as follows: The northern boundary, the parallel of 36° 30′; the southern boundary, a line running northwest from Goat Island on the coast in latitude 33° 56′ to the parallel of 35°, and thence along that parallel to Tennessee; while the western boundary is the Smoky Mountains. It is strange that the Revised Statutes should contain such a statement of the boundary lines when it is thoroughly well known that it is incorrect, especially as regards the southern boundary. In the case of the northern boundary the intention has been from the earliest colonial times down to the present to establish a line upon the parallel of 36° 30′. This is found to be the wording of every legislative act relating to it, and the errors of this boundary are due simply to errors in surveying and location. The following brief and comprehensive sketch of the north and south boundary lines of this State, and of the various attempts made to locate them, is taken from Professor Kerr's "Geology of North Carolina," vol. I, page 2:

"The first and only serious attempt to ascertain the northern boundary was that made in 1728, by Col. Wm. Byrd, and others, commissioners on the part of the two colonies, acting under Royal authority. From the account given by Byrd of this undertaking, it appears that they started from a point on the coast whose position they determined by observation to be in 36° 31′, north latitude, and ran due west (correcting for the variation of the compass), to Nottoway River, where they made an offset of a half mile to the mouth of that stream, again running west. The line was run and marked 242 miles from the coast, to a point in Stokes County, on the upper waters of the Dan River (on Peter's creek) the North Carolina commissioners accompanying the party only about two-thirds of the distance. Beyond this point, the line was carried some 90 miles by another joint commission of the two colonies in 1749; this survey, terminating at Steep Rock Creek, on the east of Stone Mountain, and near the present northwest corner of the State, was estimated to be 329 miles from the coast. In 1779 the line was taken up again at a point on Steep Rock Creek, determined by observation to be on the parallel of 36° 30′ (the marks of the previous survey having disappeared entirely), and carried west to and beyond Bristol, Tennessee. This last is known as the Walker line, from one of the commissioners of Virginia.

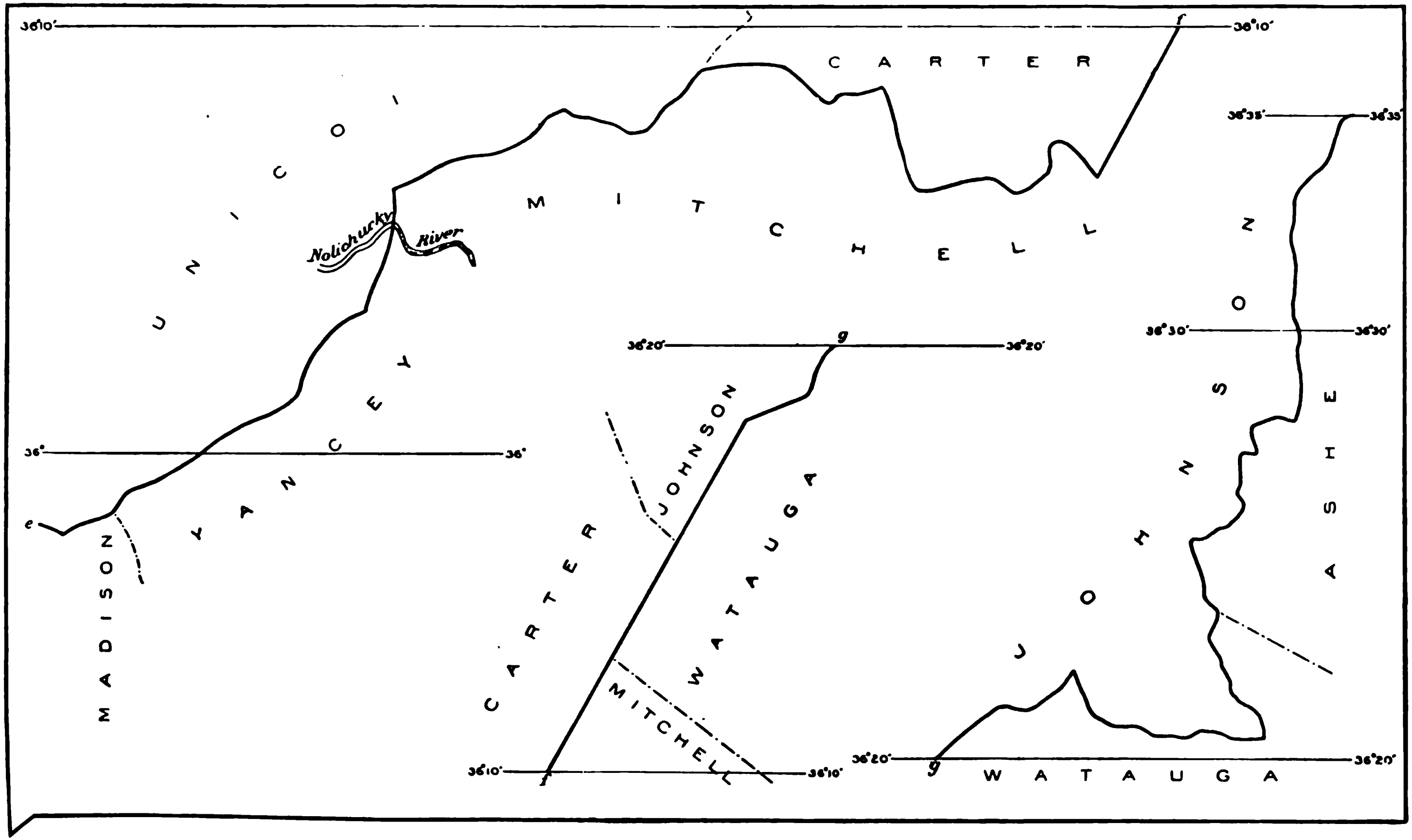
These lines were run and the latitude observations taken with very imperfect instruments, and the variation of the compass was little understood, so that it was not possible to trace a parallel of latitude. The line, besides, was only marked on the trees and soon disappeared, and as the settlements were very scattered the location soon became a matter of vague tradition and presently of contention and litigation, so that in 1858, at the instance of Virginia, commissioners were appointed to relocate the line from the end of the Byrd survey westward, but for some reason they did not act. In 1870 commissioners were again appointed by Virginia and similar action asked on the part of this State; and the proposition was renewed in 1871, but ineffectually, as before. In all these numerous attempts to establish the line of division between the two colonies and States, the intention and the specific instructions have been to ascertain and mark, as the boundary of the two States, *the parallel of* 36° 30′. The maps published towards the end of last century by Jefferson and others give that parallel as the line, and the bill of rights of North Carolina claims that "all the territory lying between the line above described (the line between North and South Carolina) and the southern line of the State of Virginia, which begins on the sea shore in 36° 30′ north latitude, and from thence runs west, agreeably to the



BOUNDARY BETWEEN NORTH CAROLINA AND TENNESSEE.



BOUNDARY BETWEEN NORTH CAROLINA AND TENNESSEE.



BOUNDARY BETWEEN NORTH CAROLINA AND TENNESSEE.

charter of King Charles, are the right and property of this State." But it appears from the operations of the United States Coast Survey at both ends of the line that the point of beginning on Currituck Inlet, instead of being, as so constantly assumed, in latitude 36° 30′, or as determined by the surveyors in 1728, 36° 31′ is 36° 33′ 15″, and the western end (of "the Walker line," of 1779, at Bristol, Tenn.) 36° 34′ 25.5″. It is stated in Byrd's Journal that the variation of the compass was ascertained to be a little less than 3° W. [The magnetic chart of the United States Coast Survey would make it 3° E.] And no account is given of any subsequent correction, and if none was made at the end of the line surveyed by him the course would have been in error by nearly 3°, as the amount of variation in this State changes a little more than 1° for every 100 miles of easting or westing. So that the northern boundary of the State as run is not only not the parallel of 36° 30′, but is far from coincident with any parallel of latitude, and must be a succession of curves, with their concavities northward and connected at their ends by north and south offsets.

The southern boundary between this State and South Carolina and Georgia was first established by a joint colonial commission in 1735 to 1746. The commissioners run a line from Goat Island on the coast (in latitude 33° 56′ as supposed) NW to the parallel of 35°, according to their observations, and then due west to within a few miles of the Catawba River, and here, at the old Salisbury and Charleston road, turned north along that road to the southeast corner of the Catawba Indian Lands. This line, resurveyed in 1764, was afterwards (in 1772) continued along the eastern and northern boundaries of the Catawba lands to the point where the latter intersects the Catawba River; thence along and up that river to the mouth of the South Fork of the Catawba, and thence due west, as supposed, to a point near the Blue Ridge. This part of the line was resurveyed and confirmed by commissioners under acts of assembly of 1803, 1804, 1806, 1813, 1814, and 1815, and continued west to and along the Saluda Mountains and the Blue Ridge to the intersection of the "Cherokee boundary" of 1797, and thence in a direct line to the Chatooga River at its intersection with the parallel of 35°. From this point the line was run west to the Tennessee line, between this State and Georgia, in 1807, and confirmed and established by act of 1819.

The boundary between this State and Tennessee was run, according to the course designated in the act of 1789, entitled "An act for the purpose of ceding to the United States certain western lands therein described" (the State of Tennessee); that is, along the crest of the Smoky Mountains, from the Virginia line to the Cataluche River (in Haywood County), in 1799, under act of 1796. It was continued from this point to the Georgia line in 1821. The commissioners who completed this line, at the date last-mentioned, instead of following their instructions, diverged from the crest of the Smoky (Unaka) Mountains at the intersection of the Hiwassee turnpike, and run *due south* to the Georgia line, thereby losing for the State the valuable mining region since known as Ducktown.

And as to the southern boundary, the point of beginning on Goat Island is in latitude 33° 51′ 37″, as shown by the Coast Survey, and instead of running from Goat Island northwest to latitude of 35° and thence along that parallel, it appears, from the South Carolina Geographical State Survey of 1821-'25, that the course from the starting point is N. 47° 30′ W., and instead of pursuing the parallel of 35° it turns west about 10 miles south of that line, and then on approaching the Catawba River, turns northward pursuing a zigzag line to the forks of the Catawba River, which is about 12 miles north of that parallel; and from this point to the mountains the boundary line (of 1772) runs, not west, but N. 88° W., bringing its western end about 17 miles too far north, and reaching the (supposed) parallel of 35° at a distance of about 130 miles east of the Catawba River. The loss of territory resulting from these singular deviations is probably between 500 and 1,000 square miles.

The following extract from the constitution of 1796, of Tennessee, defines the eastern boundary of that State, which is the western boundary of North Carolina, as it was intended to be run and marked:

> Beginning on the extreme height of the Stone Mountain at the place where the line of Virginia intersects it in latitude thirty-six degrees and thirty minutes north; running thence along the extreme height of the said mountain to the place where Watauga River breaks through it; thence a direct course to the top of the Yellow Mountain, where Bright's road crosses the same; thence along the ridge of said mountain between the waters of Doe River and the waters of Rock Creek, to the place where the road crosses the Iron Mountain; from thence along the extreme height of said mountain to where Nolichucky River runs through the same; thence to the top of the Bald Mountain; thence along the extreme height of said mountain to the Painted Rock on French Broad River; thence along the highest ridge of said mountain to the place where it is called the Great Iron or Smoky Mountain; thence along the extreme height of said mountain to the place where it is called Unicoi or Unaka Mountain between the Indian towns of Cowee and Old Chota; thence along the main ridge of the said mountain to the southern boundary of this State as described in the act of cession of North Carolina to the United States of America.

In 1879 the legislature passed an act to appoint commissioners to make a survey from the northeast corner of Georgia westward. This point of commencement is common to North Carolina, South Carolina, and Georgia.

In 1881 the legislature passed another act, providing for the appointment of a commissioner, who should act with commissioners from Virginia, South Carolina, Georgia, or Tennessee, to re-run and re-mark the boundaries between North Carolina and the other States.

SOUTH CAROLINA.

The territory included in the present State of South Carolina was included in the charter of Carolina, which also embraced what is now the State of Georgia. (*Vide* North Carolina, p. 99.)

In 1729 the province of Carolina was divided, forming the two provinces of North Carolina and South Carolina. In 1732 the extent of South Carolina was reduced by the charter of Georgia. (*Vide* Georgia, p. 103.)

(For a history of the settlement of the boundary between North Carolina and South Carolina, *vide* North Carolina, p. 99.)

By the charter of Georgia the line between South Carolina and Georgia was to be the Savannah River, to the head thereof. In 1762 difficulties having arisen, concerning the interpretation of the charter, as regarded the head of the Savannah, and also the title to the lands south of the Altamaha River, Georgia made complaint to the King, who issued a proclamation in 1763 giving the lands between the Altamaha and Saint Mary's Rivers to Georgia. The question of the boundary on the Savannah, however, remained unsettled until 1787, when a convention between the two States was held at Beaufort, S. C., to determine the same, and the line was fixed as at present.

The following is an extract from the articles of agreement:

> The most northern branch or stream of the river Savannah from the sea or mouth of such stream to the fork or confluence of the rivers now called Tugaloo and Keowa, and from thence the most northern branch or stream of the said river Tugaloo till it intersects the northern boundary line of South Carolina, if the said branch or stream of Tugaloo extends so far north, reserving all the islands in the said rivers Savannah and Tugaloo to Georgia; but if the head spring or source of any branch or stream of the said river Tugaloo does not extend to the north boundary line of South Carolina, then a west line to the Mississippi, to be drawn from the head spring or source of the said branch or stream of Tugaloo River which extends to the highest northern latitude, shall forever hereafter form the separation, limit, and boundary between the States of South Carolina and Georgia. (Laws of the United States, Vol. I, p. 466.)

In the same year South Carolina ceded to the United States a narrow strip of territory south of the North Carolina line, which she claimed, about 12 or 14 miles wide, and extending to the Mississippi River; this strip now forms the northern portion of Georgia, Alabama, and Mississippi. Georgia being thus increased in extent northwardly, the line between the two States is clearly expressed in the code of South Carolina, as follows, viz:

> The Savannah River, from its entrance into the ocean to the confluence of the Tugaloo and Keowa Rivers; thence by the Tugaloo River to the confluence of the Tugaloo and Chatooga Rivers; thence by the Chatooga River to the North Carolina line in the thirty-fifth degree of north latitude, the line being low-water mark at the southern shore of the most northern stream of said rivers, where the middle of the rivers is broken by islands, and middle thread of the stream where the rivers flow in one stream or volume.

GEORGIA.

Georgia was included in the proprietary charter granted to the lords proprietors of Carolina in 1663 and 1665, for which a provincial charter was substituted in 1719.

In 1732 the charter of Georgia as an independent colony was granted by King George II, of which the following is an extract:

> All those lands, countrys, and territories situate, lying and being in that part of South Carolina, in America, which lies from the most northern part of a stream or river there, commonly called the Savannah, all along the sea-coast to the southward, unto the most southern stream of a certain other great water or river called the Altamaha, and westerly from the heads of the said rivers, respectively, in direct lines to the south seas.

This charter was surrendered in 1752 and a provincial government established. (C. & C., p. 369 *et seq.*)

In 1763 the territory between the Altamaha and Saint Mary's Rivers was added to Georgia by royal proclamation. (*Vide* South Carolina, p. 102.)

In the constitution adopted by Georgia in 1798 the boundaries are declared. The following is an extract therefrom:

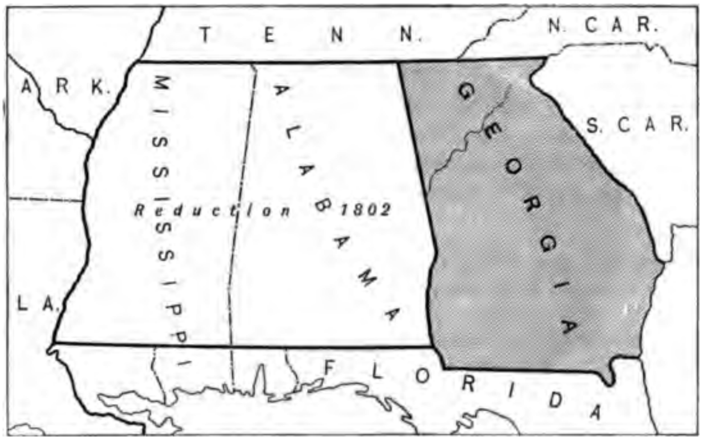
> The limits, boundaries, jurisdictions, and authority of the State of Georgia do, and did, and of right ought to extend from the sea or mouth of the river Savannah along the northern branch or stream thereof, to the fork or confluence of the rivers now called Tugalo and Keowee, and from thence along the most northern branch or stream of the said river Tugalo, till it intersect the northern boundary line of South Carolina, if the said branch or stream of Tugalo extends so far north, reserving all the islands in the said rivers Savannah and Tugalo to Georgia; but if the head, spring, or source of any branch or stream of the said river Tugalo does not extend to the north boundary line of South Carolina, then a west line to the Mississippi, to be drawn from the head, spring, or source of the said branch or stream of Tugalo River, which extends to the highest northern latitude; thence down the middle of the said river Mississippi, until it shall intersect the northernmost part of the thirty-first degree of north latitude, south by a line drawn due east from the termination of the line last mentioned, in the latitude of thirty-one degrees north of the equator, to the middle of the river Apalachicola or Chatahoochee; thence along the middle thereof, to its junction with Flint River; thence straight to the head of Saint Mary's River, and thence, along the middle of Saint Mary's River, to the Atlantic Ocean, and from thence to the mouth or inlet of Savannah River, the place of beginning, including and comprehending all the lands and waters within the said limits, boundaries, and jurisdictional rights; and also all the islands within twenty leagues of the sea-coast.

In 1802 Georgia entered into articles of agreement and cession with the United States, whereby Georgia ceded to the United States the lands west of her present boundaries, and the United States ceded to Georgia that part of the South Carolina cession of 1787 which lies east of the present western boundary of Georgia. The following extracts show the limits of the two cessions:

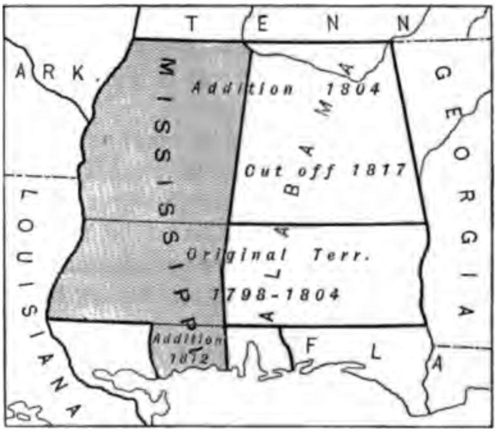
> The State of Georgia cedes to the United States all the right, title, and claim which the said State has to the jurisdiction and soil of the lands situated within the boundaries of the United States, south of the State of Tennessee and west of a line beginning on the western bank of the Chatahouchee River where the same crosses the boundary line between the United States and Spain; running thence up the said river Chatahouchee, and along the western bank thereof to the great bend thereof, next above the place where a certain creek or river, called "Uchee" (being the first considerable stream on the western side, above the Cussetas and Coweta towns), empties into the said Chatahouchee River; thence in a direct line to Nickajack, on the Tennessee River; thence crossing the said last-mentioned river, and thence running up the said Tennessee River and along the western bank thereof to the southern boundary line of the State of Tennessee.
>
> * * * * * * *
>
> The United States * * * cede to the State of Georgia * * * the lands * * * situated south of the southern boundaries of the States of Tennessee, North Carolina, and South Carolina, and east of the boundary line herein above described as the eastern boundary of the territory ceded by Georgia to the United States.

For a history of the boundary between Georgia and South Carolina, *vide* South Carolina, p. 102.

The history of the boundary between North Carolina and Georgia has already been given (*vide* North Carolina, p. 101). It may be proper, however, to add that this line (the thirty-fifth degree of north latitude) was fixed by the cession above detailed, from the United States to Georgia



HISTORICAL DIAGRAM OF GEORGIA.



HISTORICAL DIAGRAM OF MISSISSIPPI.

of that part of the South Carolina cession east of the present western boundary of Georgia.

A long controversy ensued between Georgia and North Carolina, with no results, however, until in 1810 Georgia empowered her governor to employ Mr. Andrew Ellicott to ascertain the true location of the thirty-fifth degree of latitude. Ellicott did so, and the point fixed by him was acquiesced in. (*Vide* Cobb's Georgia Digest, p. 150.)

The boundary between Georgia and Tennessee was established in 1818, and is as follows, viz: The thirty-fifth parallel of north latitude, beginning and ending as follows:

> Beginning at a point in the true parallel of the thirty-fifth degree of north latitude, as found by James Cormack, mathematician on the part of the State of Georgia, and James S. Gaines, mathematician on the part of the State of Tennessee, on a rock about two feet high, four inches thick, and fifteen inches broad, engraved on the north side thus: "June 1st, 1818; var. 6¾ east," and on the south side thus: "Geo. 35 North; J. Cormack," which rock stands one mile and twenty-eight poles from the south bank of the Tennessee River, due south from near the center of the old Indian town of Nickajack, and near the top of the Nickajack Mountain, at the supposed corner of the State of Georgia and Alabama; thence running due east, leaving old D. Ross two miles and eighteen yards in the State of Tennessee, and leaving the house of John Ross about two hundred yards in the State of Georgia, and the house of David McNair one mile and one-fourth of a mile in the State of Tennessee, with blazed and mile-marked trees, lessening the variation of the compass by degrees, closing it at the termination of the line on the top of the Unicoi Mountain at five and one-half degrees. (*Vide* C. Stat. of Tenn., pp. 243–244.)

The boundary between Georgia and Florida was fixed by the treaty of 1783, between the United States and Great Britain, substantially as at present, viz: Commencing in the middle of the Apalachicola or Catahouche River, on the thirty-first degree of north latitude; thence along the middle thereof to its junction with the Flint River; thence straight to the head of Saint Mary's River, and thence down along the middle of Saint Mary's River to the Atlantic ocean (*vide* Treaty of 1783). This boundary was affirmed by the treaty of 1795 between the United States and Spain, and commissioners were appointed to run the entire line between the United States and the Spanish territory. (*Vide* Treaty of 1795.)

In 1819 Spain ceded the Floridas to the United States. In 1822 Florida was made a Territory and in 1825 was admitted into the Union as an independent State.

In 1826 Congress took action as indicated below:

UNITED STATES STATUTES AT LARGE, NINETEENTH CONGRESS, SESSION I, 1826.

AN ACT to authorise the President of the United States to run and mark a line dividing the Territory of Florida from the State of Georgia.

The line shall be run straight from the junction of said rivers Chatahoochie and Flint, to the point designated as the head of Saint Mary's River.

This boundary line was long unsettled, a controversy arising concerning the true point to be considered to be the head of the Saint Mary's

River, as Georgia contended that the point fixed upon by the Spanish and American commissioners under the treaty of 1795 was incorrect. This line was run in 1825 by the General Land Office.

In 1859 commissioners were appointed by Georgia and Florida to rerun the line. Florida ratified their report in 1861, and Georgia in 1866.

The detailed report of the commissioners is not at hand, but the line is declared in the statutes of Georgia as follows, viz:

> From a point on the western bank of the Chattahoochee River in the 31st degree of north latitude; thence along the line or limit of high-water mark to its junction with the Flint River; thence along a certain line of survey made by Gustavus J. Orr, a surveyor on the part of Georgia, and W. Whitner, a surveyor on the part of Florida, beginning at a four-and-aft tree, about four chains below the present junction; thence along this line east, to a point designated thirty-seven links north of Ellicott's Mound on the St. Mary's River; thence along the middle of said river to the Atlantic Ocean. (*Vide* Code of Ga., 1873, p. 7.)

This line is also given in the code of Florida, and differs in one respect, viz, from the thirty-first degree of north latitude down the middle of said river to its confluence with the Flint River, etc. (*Vide* Code of Florida, 1872.)

The line between Georgia and Alabama was fixed by the act of cession of Georgia to the United States in 1802.

In 1822–'25, Georgia desiring to have the line run from the Chattahoochee to where it strikes the Tennessee line, appointed commissioners for that purpose, and requested the co-operation of Alabama and the United States, both, however, failing to take action. The Georgia commissioners ran the line from Nickajack, on the Tennessee line, to Miller's Bend, on the Chattahoochee. (For a history of the controversy concerning this line, *vide* laws of Georgia, 1822–'24–'25–'26.)

Alabama protested against the above line and made repeated efforts to reopen negotiations concerning it, to all of which Georgia sturdily refused to accede, until finally, January 24, 1840, the legislature of Alabama passed the following joint resolution, viz:

> *Resolved*, That the State of Alabama will, and do, hereby accept, as the true dividing line between this State and that of Georgia, the line which was run and marked out by the commissioners of Georgia in 1826, beginning at what is called Miller's Bend, on the Chattahoochee River; thence along said marked line to Nickajack.

The line is given in the code of Alabama in the following words, viz:

> The boundary line between Alabama and Georgia commences on the west side of the Chattahoochee River at the point where it enters the State of Florida; from thence up the river, along the western bank thereof, to the point on Miller's Bend next above the place where the Uchee Creek empties into such river; thence in a direct line to Nickajack. (See code of Alabama, 1876, p. 189.)

In James's Hand-book of Georgia, 1876, p. 121, is the following description of the western boundary of Georgia, viz:

> From Nickajack the line between Georgia and Alabama runs south 9° 30′ east to Miller's Bend, on the Chattahoochee River, about 146 miles; thence down the western *bank of* the river at high-water mark to its junction with Flint River, at a point now *four* chains below the actual junction, latitude 30° 42′ 42″, longitude 80° 53′ 15″.

FLORIDA.

Florida was originally settled by the Spaniards, and was held as a Spanish province nearly two hundred years. In 1762 it was ceded by Spain to Great Britain, who divided it into the two provinces of East and West Florida, separated by the Apalachicola River, with a northern boundary substantially as at present. (*Vide* Fairbanks' History of Florida.)

In 1783 Great Britain retroceded Florida to Spain, and the northern boundary was fixed by the treaty of peace between the United States and Great Britain signed in the same year. Spain, however, claimed the territory as far north as the parallel of latitude of the mouth of the Yazoo River.

Previous to this, in 1763, France had ceded Louisiana to Spain, which Spain retroceded to France in 1800, and in 1803 France ceded the same to the United States, who claimed that the eastern boundary of the said province of Louisiana, so often ceded, was the Perdido River, while Spain claimed it to be the Iberville River and Lakes Maurepas and Pontchartrain. The controversy arising from the difference of interpretation of these various treaties and cessions was terminated by the treaty of Washington in 1819, whereby Spain ceded to the United States the provinces of East and West Florida.

On March 30, 1822, by an act of Congress, the territory ceded to the United States by Spain was made the "Territory of Florida," embracing the same extent as does the present State.

On March 3, 1845, Florida was admitted into the Union as an independent State.

(For a history of the northern boundary of Florida *vide* Georgia, p. 105.)

In 1831 Congress passed an act relating to the boundary between Florida and Alabama, of which the following is an extract:

AN ACT to ascertain and mark the line between the State of Alabama and the Territory of Florida, and the northern boundary of the State of Illinois, and for other purposes.

That the President of the United States be, and he is hereby, authorized to cause to be run and marked the boundary line between the State of Alabama and the Territory of Florida, by the surveyors-general of Alabama and Florida, on the thirty-first degree of north latitude.

* * * * * * *

(*Vide* U. S. Stat. at Large, Vol. IV, p. 479.)

In 1847 the agreement of commissioners previously appointed by Florida and Alabama was ratified, and the line is described as follows, viz:

Commencing on the Chattahoochee River near a place known as "Irwin's Mills" and running west to the Perdido, marked throughout by blazes on the trees, and also by mounds of earth thrown up on the line at distances of one mile, more or less, from each other, and commonly known as "Ellicott's Line," or the "Mound Line." (*Vide* Florida Code, 1873, p. 100.)

This line was run in 1799–1800 by A. Ellicott. The line was retraced, remeasured, and marked in 1853–54.

The line between the two States is given in general terms in the Florida Code as follows, viz:

> Commencing at the mouth of the Perdido River, from thence up the middle of said river to where it intersects the south boundary line of the State of Alabama and the thirty-first degree of north latitude; then due east to the Chattahoochee River.

ALABAMA.

In 1798 the United States formed the Territory of Mississippi, including—

> All that tract of country bounded on the west by the Mississippi, on the north by a line to be drawn due east from the mouth of the Yasous to the Chattahouchee River, on the east by the Chattahouchee River, and on the south by the thirty-first degree of north latitude. (*Vide* U. S. Stat. at Large, Vol. I, p. 549.)

In this act was a clause reserving the right of Georgia and of individuals to the jurisdiction of the soil thereof.

South Carolina and Georgia having ceded to the United States their claim to territory west of their present limits, the General Government, in 1804, by an act of Congress, annexed the tract of country lying north of Mississippi Territory and south of the State of Tennessee, and bounded on the east by Georgia and west by Louisiana, to the Territory of Mississippi. (*Vide* U. S. Stat. at Large, Vol. II, p. 305.) Also in 1812 the United States added to Mississippi Territory all the lands lying east of Pearl River, west of the Perdido and south of the thirty-first degree of latitude. (*Vide* U. S. Stat. at Large, Vol. II, p. 734.)

By these additions the Territory of Mississippi was made to comprise what is now included in the two States of Alabama and Mississippi. On March 8, 1817, by an act of Congress the Territory of Alabama was formed from the eastern portion of the Territory of Mississippi, with the following boundaries, viz:

> Beginning at the point where the line of the thirty-first degree of north latitude intersects the Perdido River; thence east to the western boundary line of the State of Georgia; thence along said line to the southern boundary line of the State of Tennessee; thence west along said boundary line to the Tennessee River; thence up the same to the mouth of Bear Creek; thence by a direct line to the northwest corner of Washington County; thence due south to the Gulf of Mexico; thence, eastwardly, including all the islands within 6 leagues of the shore, to the Perdido River; and thence up the same to the beginning. (*Vide* U. S. Stat. at Large, Vol. III, p. 371.)

On December 14, 1819, Alabama was admitted as an independent State, with the above boundaries. It was, however, made the duty of the surveyor of the public lands south of Tennessee and the surveyor of lands in Alabama Territory to run and cut out the line of demarcation between the two States of Alabama and Mississippi, and if it should appear to said surveyors that so much of the line designated as running due south from the northwest corner of Washington County to the Gulf of Mexico should encroach on the counties of Wayne, Greene, and Jackson, in the State of Mississippi, then the same should be altered so as to run in a direct line from the northwest corner of Washington County to a point on the Gulf of Mexico 10 miles east of the mouth of the River Pascagoula. (*Vide* U. S. Stat. at Large, Vol. III, p. 490.) This line was run and marked in 1820.

(For the history of the boundaries between Alabama and Georgia *vide* Georgia, p. 106. For the history of the boundaries between Alabama and Florida *vide* Florida, p. 107.)

The boundary between Alabama and Tennessee is the thirty-fifth parallel of north latitude (*vide* North Carolina, p. 101); from Nickajack (*vide* Georgia, p. 104) west across the Tennessee River, and on to the second intersection of said river by said parallel. (*Vide* Alabama Code, 1876, p. 189.)

The boundary between Alabama and Mississippi was to be run by surveyors, under the act of admission of Alabama. The report of said surveyors is not at hand, but the line as laid down in the Mississippi Code is as follows, viz:

> Beginning at a point on the west bank of the Tennessee River, six four-pole chains south of, and above, the mouth of Yellow Creek; thence up the said river to the mouth of Bear Creek; thence by a direct line to what was formerly the northwest corner of Washington County, Alabama; thence in a direct line to a point ten miles east of the Pascagoula River, on the Gulf of Mexico. (*Vide* Mississippi Code, pp. 48, 49).

MISSISSIPPI.

(For the early history of the extent of Mississippi Territory *vide* Alabama, p. 108.)

On December 10, 1817, the western part of the Mississippi Territory was made a State and admitted into the Union, with the following boundaries, viz:

> Beginning on the river Mississippi at the point where the southern boundary of the State of Tennessee strikes the same; thence east along the said boundary line to the Tennessee River; thence up the same to the mouth of Bear Creek; thence by a direct line to the northwest corner of the county of Washington; thence due south to the Gulf of Mexico; thence westwardly, including all the islands within six leagues of the shore, to the most eastern junction of Pearl River with Lake Borgne; thence up said river to the thirty-first degree of north latitude; thence west along said degree of latitude to the Mississippi River; thence up the same to the beginning. (*Vide* U. S. Stat. at Large, Vol. III, p. 348.)

(For further information concerning eastern boundary, *vide* Alabama, p. 108.)

In 1819 the line between Mississippi and Tennessee was run by commissioners. Their report is not at hand. In 1833 the legislature of

Tennessee passed an act establishing "Thompson's line." The details of "Thompson's line" have not been found. In 1837 the line was again run by commissioners from the two States, and ratified by the legislatures. The commissioners' report was as follows, viz:

> Commencing at a point on the west bank of the Tennessee River six four-pole chains south, or above the mouth of Yellow Creek, and about three-quarters of a mile north of the line known as "Thompson's line," and twenty-six chains and ten links north of Thompson's line at the basis meridian of the Chickasaw surveys, and terminating at a point on the east bank of the Mississippi River (opposite Cow Island) sixteen chains north of Thompson's line. (See Laws of Tennessee, 1837, p. 27.)

The boundaries were fixed by the act of Congress admitting the State of Mississippi, as follows, viz:

> Commencing at the most eastern junction of Pearl River with Lake Borgne, thence up said Pearl River to the thirty-first degree of north latitude, thence west along said degree of latitude to the Mississippi River, thence up the same to the point where the southern boundary of Tennessee strikes the same. (See U. S. Laws, vol. 6, p. 175.)

Mississippi claims to the middle of the Mississippi River, where the river forms her western boundary. (See Rev. Stat., 1857.)

LOUISIANA.

The original territory of Louisiana was acquired from France (see p. 21). In 1804, a portion of this, comprising the area of the present State of Louisiana, with the exception of the southeastern portion immediately adjoining the present State of Florida, was organized into a territory under the name of Orleans, while the balance of the Louisiana purchase retained the name of Louisiana Territory. On April 30, 1812, the Territory of Orleans was admitted as a State under the name of Louisiana, and at the same time the name of the Territory of Louisiana was changed to Missouri Territory. In the same year the limits of the State were enlarged in the southeast to its present boundaries.

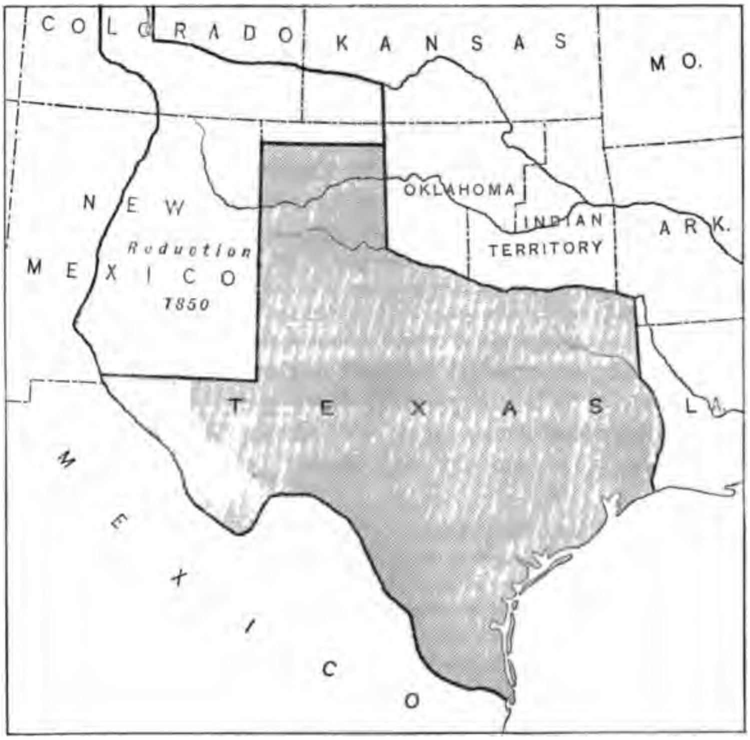
The following act defines the Territory of Orleans:

> All that portion of country ceded by France to the United States, under the name of Louisiana, which lies south of the Mississippi territory, and of an east and west line to commence on the Mississippi River at the thirty-third degree of north latitude, and to extend west to the western boundary of the said cession, shall constitute a Territory of the United States, under the name of the Territory of Orleans. (Eighth Congress, first session.)

The following clause from the act admitting Louisiana defines its original boundaries:

> Beginning at the mouth of the river Sabine, thence by a line to be drawn along the middle of said river, including all islands, to the thirty-second degree of latitude; thence due north to the northernmost part of the thirty-third degree of north latitude; thence along the said parallel of latitude to the river Mississippi; thence down

HISTORICAL DIAGRAM OF LOUISIANA.



HISTORICAL DIAGRAM OF TEXAS.

the said river to the river Iberville; and from thence along the middle of the said river and lakes Maurepas and Pontchartrain to the Gulf of Mexico; thence, bounded by the said Gulf, to the place of beginning, including all islands within three leagues of the coast. (Twelfth Congress, first session.)

The following is a description of the addition to the State of Louisiana, in terms of the act:

Beginning at the Junction of the Iberville with the river Mississippi, thence along the middle of the Iberville, the river Amite, and of the lakes Maurepas and Pontchartrain, to the eastern mouth of the Pearl River; thence up the eastern branch of Pearl River to the thirty-first degree of north latitude; thence along the said degree of latitude to the river Mississippi; thence down the said river to the place of beginning, shall become and form a part of the State of Louisiana. (Twelfth Congress, first session.)

The north boundary of Louisiana was surveyed by a joint commission of the State and the United States.

TEXAS.

Texas declared its independence of Mexico in 1835. On December 29, 1845, it was admitted to the Union. As originally constituted, it embraced besides its present area the region east of the Rio Grande, now in New Mexico, extending north to the forty-second parallel, its eastern limits coinciding with the western limit of the United States, as laid down in the treaty with Spain of 1819. (See "Texas accession," p. 24.)

In 1848, the eastern boundary of the State was extended slightly, as noted in the following act:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Congress consents that the legislature of the State of Texas, may extend her eastern boundary so as to include within her limits one-half of Sabine Pass, one-half of Sabine Lake, also one-half of Sabine River, from its mouth as far north as the thirty-second degree of north latitude.

In 1850, the State sold to the General Government for the sum of $10,000,000, that part lying north of the parallel of 36° 30′, and that portion lying west of longitude 103°, as far south as the parallel of 32°, as set forth in the following clause from the act of Congress relating to this transfer:

First. The State of Texas will agree that her boundary on the north shall commence at the point at which the meridian of one hundred degrees west from Greenwich is intersected by the parallel of thirty-six degrees thirty minutes north latitude, and shall run from said point due west to the meridian of one hundred and three degrees west from Greenwich; thence her boundary shall run due south to the thirty-second degree of north latitude; thence on the said parallel of thirty-two degrees of north latitude to the Rio Bravo del Norte, and thence with the channel of said river to the Gulf of Mexico. (Thirty-first Congress, first session.)

The following act defines the northern boundary of Texas:

AN ACT to authorize the President of the United States, in conjunction with the State of Texas, to run and mark the boundary lines between the Territories of the United States and the State of Texas.

Beginning at the point where the one hundredth degree of longitude west from Greenwich crosses Red River, and running thence north to the point where said one hundredth degree of longitude intersects the parallel of thirty-six degrees thirty minutes north latitude, and thence west with the said parallel of thirty-six degrees and thirty minutes north latitude to the point where it intersects the one hundred and third degree of longitude west from Greenwich; and thence south with the said one hundred and third degree of longitude to the thirty-second parallel of north latitude; and thence west with said thirty-second degree of north latitude to the Rio Grande. (Thirty-fifth Cong., first session.)

The boundary line of Texas is as follows: Beginning in the Gulf of Mexico, at the outlet of Sabine Lake, the line passes northward through the middle of Sabine Lake and up the middle of Sabine River to the point where said river intersects the parallel of 32°; thence north along the meridian of that point of intersection to the point where said meridian intersects Red River; thence up Red River to the one hundredth meridian west of Greenwich; thence north on said meridian to the parallel of 36° 30′; west on said parallel to the meridian of 103° west of Greenwich; thence south on said meridian to the parallel of latitude of 32°; thence west on that parallel to its point of intersection with the Rio Grande; thence down the mid-channel of the Rio Grande to its mouth.

That portion of the east boundary between Red River and the Sabine was run and marked by a joint commission of the United States and Texas in 1841.

The boundary lines between Texas and New Mexico were run and marked in 1859–60, under the Department of the Interior.

ARKANSAS.

The Territory of Arkansas, or Arkansaw, as it was originally spelled, was formed on March 2, 1819, from a part of Missouri Territory. The following clause from the act establishing it defines its limits in part:

All that part of the Territory of Missouri which lies south of a line beginning on the Mississippi River at thirty-six degrees north latitude, running thence west to the river St. François, thence up the same to thirty-six degrees thirty minutes north latitude, and thence west to the western Territorial boundary line, shall, for the purposes of a Territorial government, constitute a separate Territory and be called the Arkansaw Territory.

In 1824 an act was passed by Congress fixing the western boundary of the Territory. This was as follows:

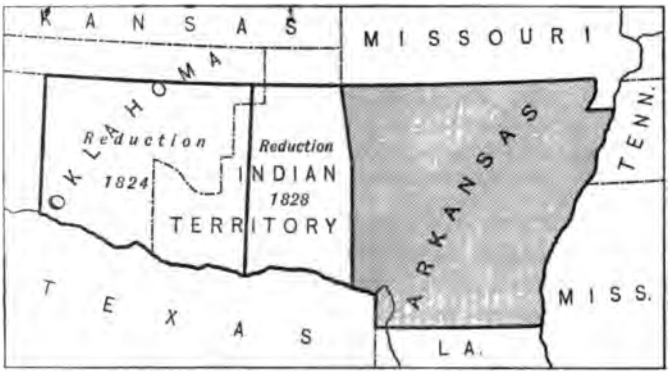
AN ACT to fix the western boundary line of the Territory of Arkansas, and for other purposes.

The western boundary line of the Territory of Arkansas shall begin at a point forty miles west of the southwest corner of the State of Missouri and run south to the right bank of the Red River, and thence down the river and with the Mexican boundary to the line of the State of Louisiana.

Four years later, in 1828, the following act was passed defining its southern boundary:

AN ACT to authorize the President of the United States to run and mark a line dividing the Territory of Arkansas from the State of Louisiana.

Commencing on the right bank of the Mississippi River at latitude thirty-three degrees north and running due west on that parallel of latitude to where a line running due north from latitude thirty-two degrees north on the Sabine River will intersect the same.



HISTORICAL DIAGRAM OF ARKANSAS.

HISTORICAL DIAGRAM OF OHIO.

The south boundary was originally run in 1823, and again in 1843–45, by a joint commission of the two States of Arkansas and Missouri.

The same year the following treaty changed materially the western line of the Territory, placing it in its present position:

TREATY WITH THE CHEROKEE INDIANS MAY 28, 1828.

ARTICLE 1. The western boundary of Arkansas shall be, and the same is, hereby defined, viz: A line shall be run, commencing on Red River at the point where the Eastern Choctaw line strikes said river, and run due north with said line to the river Arkansas; thence in a line to the southwest corner of Missouri.

The Eastern Choctaw line, referred to above, starts on the Arkansas River "one hundred paces west of Fort Smith, and thence due south to the Red River." (Treaty with Choctaw Nation, January 20, 1825.)

This part of the west boundary was run and marked in 1825, and that part from Fort Smith to the southwestern corner of Missouri in 1831. The entire western boundary was resurveyed and re-marked in 1877.

Arkansas was admitted as a State June 15, 1836.

The following extracts from the enabling act, and from various constitutions, give statements of the boundaries, differing slightly from one another, but, for the most part, only in wording:

CONSTITUTION OF ARKANSAS, 1836.

Beginning in the middle of the main channel of the Mississippi River on the parallel of 36 degrees north latitude; running from thence west with the parallel of latitude to the Saint Francis River; thence up the middle of the main channel of said river to the parallel of thirty-six degrees thirty minutes north; from thence west to the southwest corner of the State of Missouri; and from thence to be bounded on the west to the north bank of Red River, as by acts of Congress and treaties heretofore defining the western limits of the Territory of Arkansas, and to be bounded on the south side of Red River by the Mexican boundary line to the northwest corner of the State of Louisiana; thence east by the Louisiana State line to the middle of the main channel of the Mississippi River; thence up the middle of the main channel of said river to the thirty-sixth degree of north latitude, the point of beginning.

Again, in the enabling act for Arkansas, 1836 (Twenty-fourth Congress, first session), the boundaries are found to be defined as follows:

Beginning in the middle of the main channel of the Mississippi River, on the parallel of thirty-six degrees north latitude, running from thence west, with the said parallel of latitude, to the St. Francis River; thence up the middle of the main channel of said river to the parallel of thirty-six degrees thirty minutes north; from thence west to the southwest corner of the State of Missouri; and from thence to be bounded on the west, to the north bank of Red River, by the line described in the first article of the treaty between the United States and the Cherokee Nation of Indians, west of the Mississippi, made and concluded at the city of Washington, on the twenty-sixth day of May, in the year of our Lord one thousand eight hundred and twenty-eight; and to be bounded on the south side of Red river by the Mexican boundary line to the northwest corner of the State of Louisiana; thence east with the Louisiana State line to the middle of the main channel of the Mississippi River; thence up the middle of the main channel of the said river to the thirty-sixth degree of north latitude, the point of beginning.

In the constitution of 1864 the boundaries are defined as follows:

> Beginning in the middle of the Mississippi River, on the parallel of thirty-six degrees north latitude, to the St. Francis River; thence up the middle of the main channel of said river to the parallel of thirty-six degrees thirty minutes north, thence west to the southwest corner of the State of Missouri; and from thence to be bounded on the west to the north bank of Red River, as by acts of Congress of the United States, and the treaties heretofore defining the western limits of the Territory of Arkansas; and to be bounded on the south side of Red River by the boundary line of the State of Texas, to the northwest corner of the State of Louisiana; thence east with the Louisiana State line to the middle of the main channel of the Mississippi River; thence up the middle of the main channel of said river to the thirty-sixth degree of north latitude, the point of beginning.

The constitution of 1868 differs but slightly from the last. It is as follows:

> Beginning at the middle of the main channel of the Mississippi River, on the parallel of 36° north latitude, running from thence west, with the said parallel of latitude, to the Saint Francis River; thence up the middle of the main channel of said river to the parallel of 36° 30′ north; from thence west with the boundary line of the State of Missouri to the southwest corner of that State; and thence to be bounded on the west to the north bank of Red River, as by acts of Congress and treaties heretofore defining the western limits of the Territory of Arkansas; and to be bounded on the south side of Red River by the boundary line of the State of Texas to the northwest corner of the State of Louisiana; thence east with the Louisiana State line to the middle of the main channel of the Mississippi River; thence up the middle of the main channel of said river, including an island in said river known as "Belle Point Island," to the 36° of north latitude, the place of beginning.

In the constitution of 1874 there are again slight differences, mainly in wording.

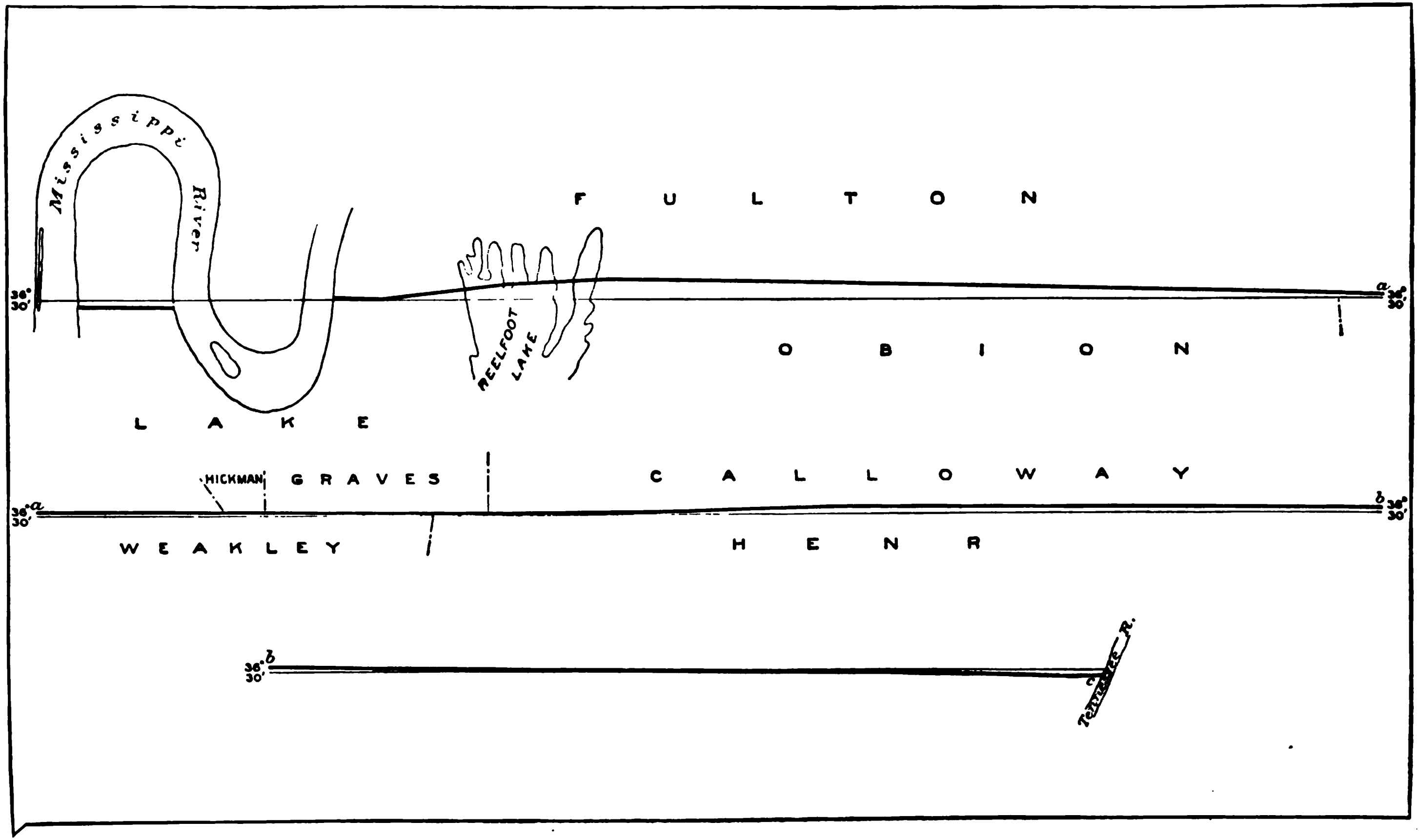
> Beginning at the middle of the main channel of the Mississippi River, on the parallel of thirty-six degrees of north latitude; running thence west with said parallel of latitude to the middle of the main channel of the Saint Francis River; thence up the main channel of said last-named river to the parallel of thirty-six degrees thirty minutes of north latitude; thence west with the southern boundary line of the State of Missouri to the southwest corner of said last-named State; thence to be bounded on the west to the north bank of Red River, as by act of Congress and treaties existing January 1, 1837, defining the western limits of the Territory of Arkansas and to be bounded across and south of Red River by the boundary line of the State of Texas as far as to the northwest corner of the State of Louisiana; thence easterly with the northern boundary line of said last-named State, to the middle of the main channel of the Mississippi River; thence up the middle of the main channel of said last-named river, including an island in said river known as "Belle Point Island," and all other land originally surveyed and included as a part of the Territory or State of Arkansas to the thirty-sixth degree of north latitude, the place of beginning.

TENNESSEE.

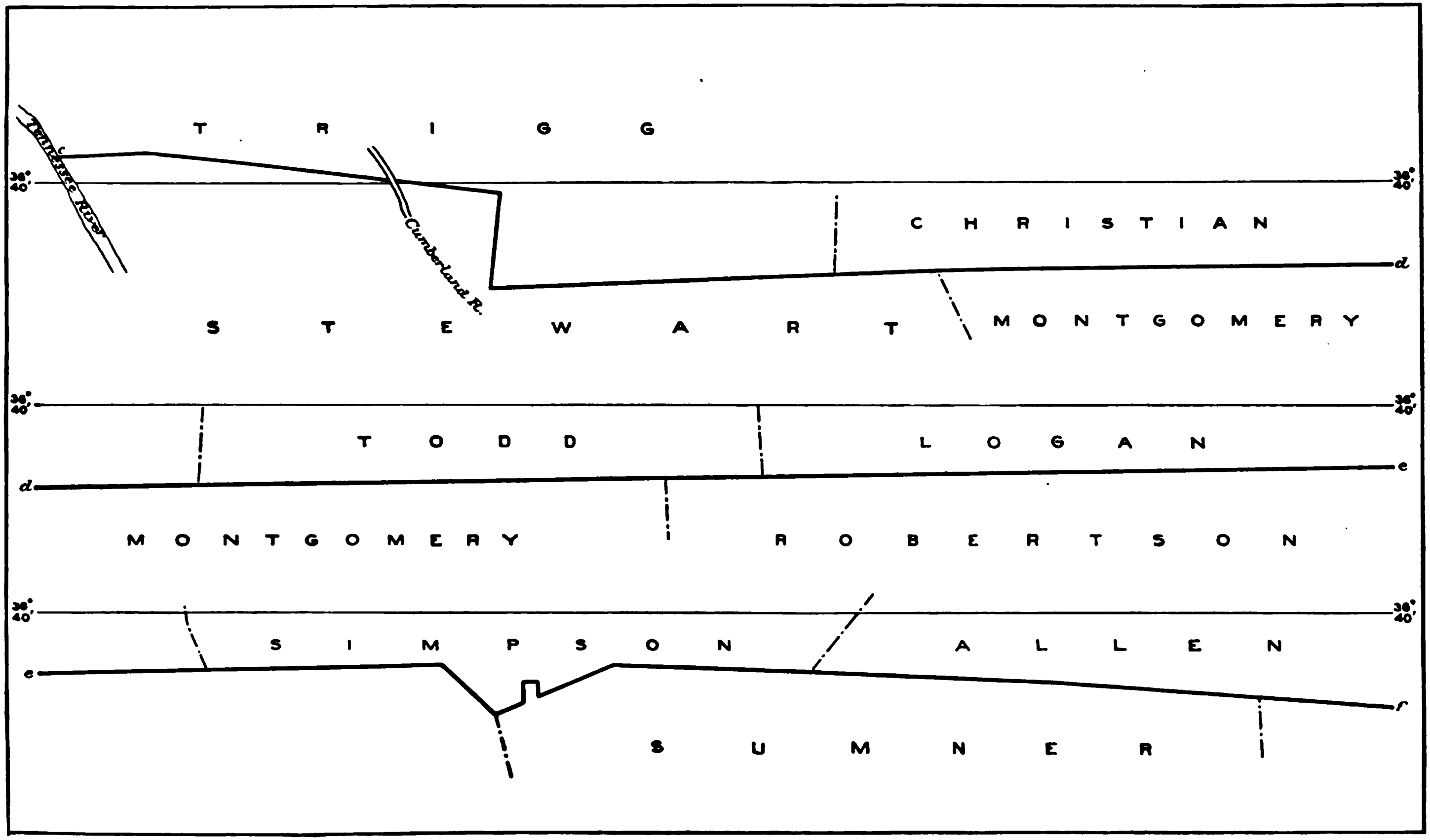
Tennessee was originally a part of North Carolina. (For further information *vide* North Carolina, p. 98.)

In 1790 it was ceded to the United States. Its boundaries described in the act of cession are, substantially, those of the present day.

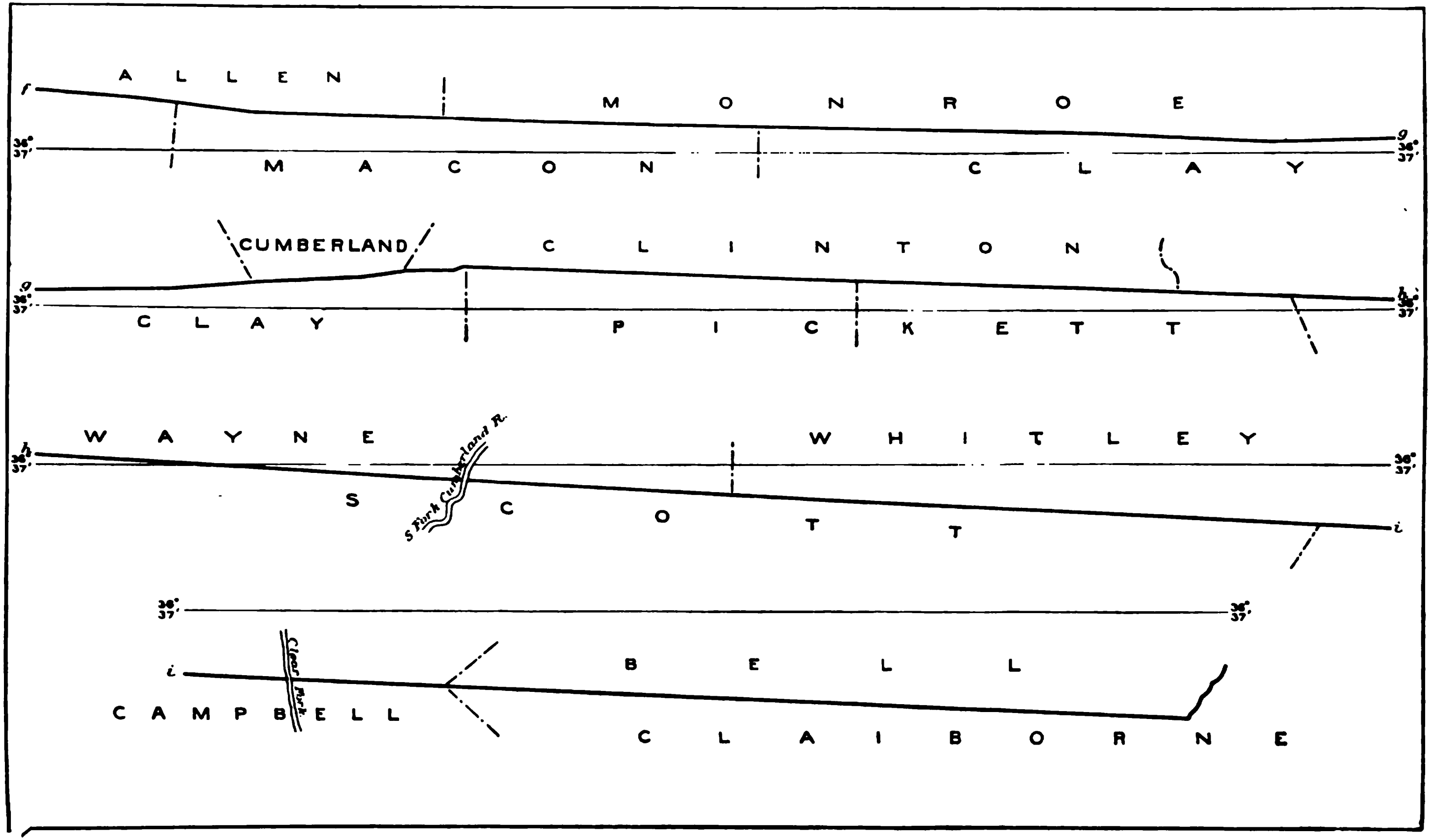
On June 1, 1796, by an act of Congress it was admitted into the Union. The act of admission declares its boundaries as "All the territory ceded by North Carolina."



BOUNDARY BETWEEN KENTUCKY AND TENNESSEE.



BOUNDARY BETWEEN KENTUCKY AND TENNESSEE.



BOUNDARY BETWEEN KENTUCKY AND TENNESSEE.

(For the history of the eastern boundary, *vide* North Carolina, p. 101; for the southern boundary, *vide* Georgia, p. 105, Alabama, p. 109, and Mississippi, p. 109.)

The Mississippi River forms its western boundary under the treaty of peace of 1783.

The line which divided Virginia and North Carolina was the southern boundary of Kentucky. Virginia and North Carolina, prior to the creation of the States of Kentucky and Tennessee, appointed commissioners, Messrs. Walker and Henderson, to run and mark the line on the parallel of latitude 36° 30′. From a point on the top of the Cumberland Mountains, now the southeastern corner of Kentucky, Walker ran and marked the line to a point on the Tennessee River. This line, called Walker's line, was regarded for many years as the dividing line between Kentucky and Tennessee. It was ascertained, however, that Walker's line was north of latitude 36° 30′.

The Indian title to the land west of the Tennessee River being extinguished by the treaty of 1819, the legislature appointed Robert Alexander and Luke Munsell to ascertain the true point of latitude 36° 30′ on the Mississippi River, and to run and mark a line east on that parallel, which was done as far east as the Tennessee River. (For above, see Gen. Stat. Ky., 1873, p. 167.)

In 1820 commissioners were appointed by Kentucky and Tennessee, respectively, to settle the boundary. Their report was ratified, and is as follows, viz:

> ART. I. The line of boundary and separation between the States of Kentucky and Tennessee shall be as follows, viz:
>
> The line run by the Virginia commissioners in the year 1779–'80, commonly called Walker's line, as the same is reputed, understood, and acted upon by the said States, their respective officers and citizens, from the southeastern corner of Kentucky to the Tennessee River; thence with and up said river to the point where the line of Alexander and Munsell, run by them in the last year under the authority of an act of the legislature of Kentucky entitled "An act to run the boundary line between this State and the State of Tennessee, west of the Tennessee River, approved Feb. 8, 1819," would cross said river, and thence with the said line of Alexander and Munsell, to the termination thereof on the Mississippi River below New Madrid.

Then follow nine other articles.

Article III provides for running and marking the line at any subsequent time. (See General Stat. Kentucky, page 170.)

In 1858–'59 commissioners were appointed by Kentucky and Tennessee to run this line.

The detailed report of the commission on the part of Tennessee can be found in Statutes of Tennessee, 1871, Vol. I, pages 223–243, giving courses, bearings, milestones erected, and a map of the boundary.

The report of this commission on the part of Kentucky was published at Frankfort, by the State Printer, 1860, in a pamphlet of 98 octavo pages, with latitudes and a map of the line, on a scale of 1:108,000.

(For a history of the boundary between Virginia and Tennessee, *vide* Virginia, p. 97.)

KENTUCKY.

Kentucky was included in the original limits of Virginia, and was a part of the county of Augusta. Augusta County was formed in 1738. In 1769 Botetourt County was created from a portion of Augusta County; in 1772, Fincastle from Botetourt; in 1776, Kentucky from Fincastle.

The boundaries of all these counties may be found in Hening's Laws of Virginia, Vols. I to IX.

In 1789 Virginia passed an act giving her consent that the county of Kentucky, within her jurisdiction, should be formed into a new State. Accordingly, June 1, 1792, Kentucky was admitted into the Union, with substantially her present boundaries.

By the cession of 1784, by Virginia to the United States, of the territory northwest of the Ohio River, this river became the northwest boundary of the State of Kentucky.

The western boundary, the Mississippi, was fixed by the treaty of peace in 1783.

(For a history of the boundary between Kentucky and Virginia and West Virginia, *vide* Virginia, p. 96; for the boundary between Kentucky and Tennessee, *vide* Tennessee, p. 115.)

OHIO.

Ohio was the first State formed from the original territory northwest of the river Ohio. It was admitted as a State on November 29, 1802, with limits given in the enabling act as follows:

> Bounded on the east by the Pennsylvania line, on the south by the Ohio River, to the mouth of the Great Miami River, on the west by the line drawn due north from the mouth of the Great Miami aforesaid, and on the north by an east and west line drawn through the southerly extreme of Lake Michigan, running east after intersecting the due-north line aforesaid, from the mouth of the Great Miami until it shall intersect Lake Erie or the territorial line; and thence with the same through Lake Erie to the Pennsylvania line aforesaid: *Provided*, That Congress shall be at liberty at any time hereafter either to attach all the territory lying east of the line to be drawn due north from the mouth of the Miami aforesaid to the territorial line, and north of an east and west line drawn through the southerly extreme of Lake Michigan, running east as aforesaid to Lake Erie, to the aforesaid State, or dispose of it otherwise, in conformity to the fifth article of compact between the original States and the people and States to be formed in the territory northwest of the river Ohio. (Seventh Congress, first session.)

In the constitution of Ohio of 1802, Article VII, the boundaries are defined as follows:

> Bounded on the east by the Pennsylvania line; on the south by the Ohio River, to the mouth of the Great Miami River; on the west by the line drawn due north from the mouth of the Great Miami aforesaid; and on the north by an east and west line drawn through the southerly extreme of Lake Michigan, running east after intersecting the due-north line aforesaid from the mouth of the Great Miami, until it shall intersect Lake Erie or the territorial line; and thence with the same through Lake Erie to the Pennsylvania line aforesaid; provided always, and it is hereby fully understood and declared by this convention, that if the southerly bend or extreme of Lake Michigan should extend so far south that a line drawn due east from it should

not intersect Lake Erie, or if it should intersect the said Lake Erie east of the mouth of the Miami River of the Lake, then, and in that case, with the assent of the Congress of the United States, the northern boundary of this State shall be established by, and extending to, a direct line running from the southern extremity of Lake Michigan to the most northerly cape of the Miami Bay, after intersecting the due-north line from the mouth of the Great Miami River as aforesaid; thence northeast to the territorial line, and by the said territorial line to the Pennsylvania line.

In accordance with the provisions in the enabling act, and in the first constitution of the State, the northern boundary of the State was changed so that, instead of running on a parallel drawn from the southern extremity of Lake Michigan, it followed the arc of a great circle drawn from the southern extremity of Lake Michigan to the most northern cape of Maumee ("Miami") Bay.

Following are the texts of the acts providing for the examination of the northern boundary and making the change in the boundary:

AN ACT to provide for the taking of certain observations preparatory to the adjustment of the northern boundary line of the State of Ohio.

That the President of the United States cause to be ascertained, by accurate observation, the latitude and longitude of the southerly extreme of Lake Michigan; and that he cause to be ascertained, by like observation, the point on the Miami of the Lake which is due east therefrom, and also the latitude and longitude of the most northerly cape of the Miami Bay; also, that he cause to be ascertained, with all practicable accuracy, the latitude and longitude of the most southerly point in the northern boundary line of the United States in Lake Erie, and also the points at which a direct line drawn from the southerly extreme of Lake Michigan to the most southerly point in said northern boundary line of the United States will intersect the Miami River and Bay; and also that he cause to be ascertained, by like observation, the point in the Mississippi which is due west from the southerly extreme of Lake Michigan; and that the said observations be made and the result thereof returned to the proper Department within the current year. (Twenty-second Congress, first session, 1832.)

AN ACT to establish the northern boundary line of the State of Ohio, and to provide for the admission of the State of Michigan into the Union.

The northern boundary line of the State of Ohio shall be established at and shall be a direct line drawn from the southern extremity of Lake Michigan to the most northerly cape of the Maumee (Miami) Bay after that line, so drawn, shall intersect the eastern boundary line of the State of Indiana; and from the said north cape of the said bay northeast to the boundary line between the United States and the province of Upper Canada, in Lake Erie, and thence, with the said last-mentioned line, to its intersection with the western line of the State of Pennsylvania. (Twenty-fourth Congress, first session, 1836.)

The northern boundary was originally surveyed in 1817. The western boundary was surveyed in the same year from old Fort Recovery to the northwestern corner. South of Fort Recovery this boundary was surveyed as the first principal meridian of the General Land Office.

INDIANA.

By the act passed in the year 1800, to take effect on and after the 4th day of July of that year, the Territory Northwest of the River Ohio was divided into two parts, the eastern part to retain the old name, the western part to become the Territory of Indiana.

Under this act the Territory of Indiana was organized. The description of the boundary line between these two Territories is given in the following act establishing them:

That from and after the fourth day of July next all that part of the territory of the United States northwest of the Ohio River, which lies to the westward of a line beginning at the Ohio, opposite to the mouth of Kentucky River, and running thence to Fort Recovery, and thence north until it shall intersect the territorial line between the United States and Canada, shall, for the purpose of temporary government, constitute a separate Territory, and be called Indiana Territory.

SEC. 5. That whenever that part of the territory of the United States which lies to the eastward of a line beginning at the mouth of the Great Miami River, and running thence due north to the territorial line between the United States and Canada, shall be erected into an independent State, and admitted into the Union on an equal footing with the original States, thenceforth said line shall become and remain permanently the boundary line between such State and the Indiana Territory, anything in this act contained to the contrary notwithstanding. (Sixth Congress, first session.)

Ohio was admitted in 1802. Its western boundary, a meridian through the mouth of the Miami River, left a narrow strip of country between Ohio and the Territory of Indiana, which was by a clause in the enabling act of Ohio added to Indiana Territory. The following is the clause in question:

SEC. 3. All that part of the territory of the United States northwest of the river Ohio heretofore included in the eastern division of said Territory, and not included within the boundary herein prescribed for the said State, is hereby attached to and made a part of the Indiana Territory.

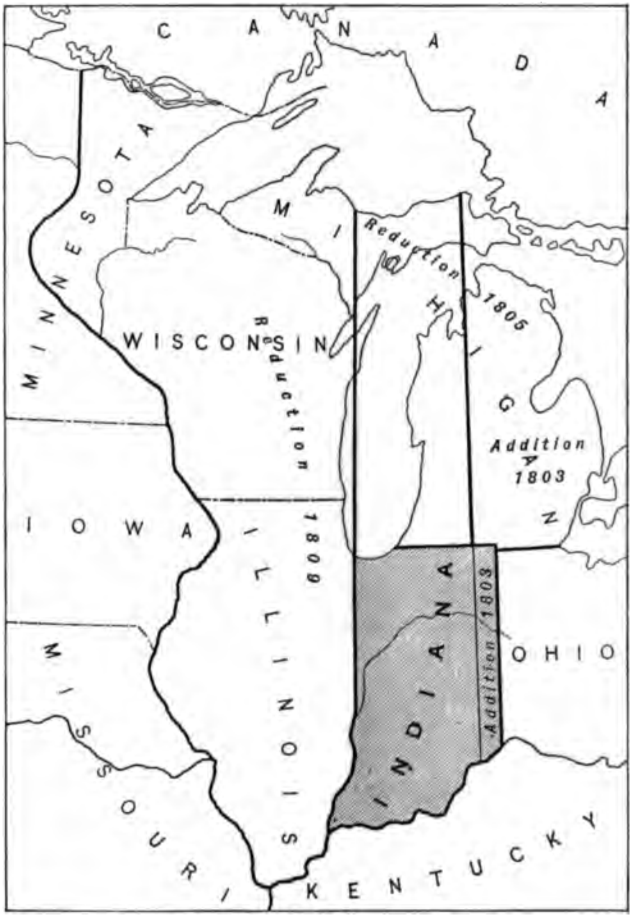
On the 30th of June, 1805, the northern portion of Indiana Territory was cut off and organized as Michigan Territory. (For the divisional line between these, see Michigan, p. 119.)

On March 1, 1809, Indiana Territory was divided, and the western portion of it organized as Illinois Territory. (For a description of the divisional line between these two Territories, see Illinois, p. 119.) On December 11, 1816, Indiana was admitted as a State with the limits as given in the following extract from the enabling act, which have not since been changed.

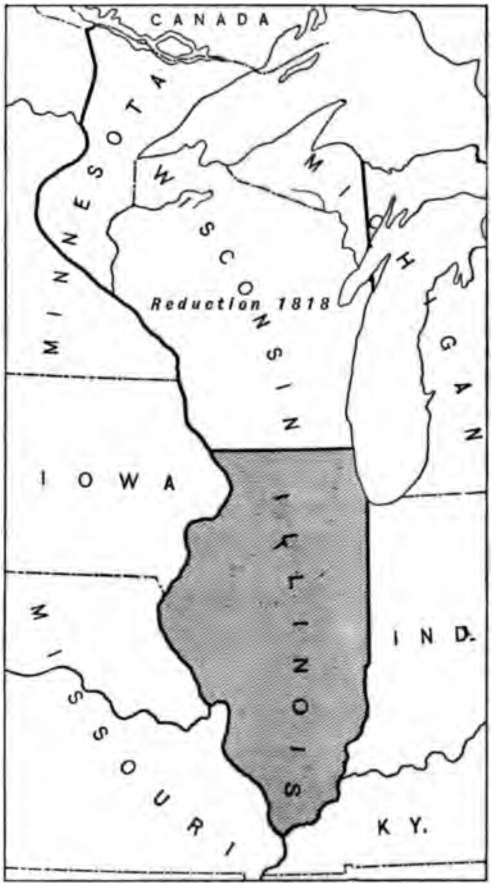
AN ACT to enable the people of the Indiana Territory to form a constitution and State government and for the admission of such State into the Union on an equal footing with the original States.

The said State shall consist of all the territory included within the following boundaries, to wit: Bounded on the east by the meridian line which forms the western boundary of the State of Ohio; on the south by the river Ohio from the mouth of the Great Miami River to the mouth of the River Wabash; on the west by a line drawn along the middle of the Wabash from its mouth to a point where a due north line drawn from the town of Vincennes would last touch the northwestern shore of the said river; and from thence by a due north line, until the same shall intersect an east and west line drawn through a point 10 miles north of the southern extreme of Lake Michigan; on the north by the said east and west line until the same shall intersect the first-mentioned meridian line which forms the western boundary of the State of Ohio. (Fourteenth Congress, first session.)

The north boundary of Indiana was surveyed and marked in 1827, and its west boundary by a joint commission of the two States, Indiana and Illinois.



HISTORICAL DIAGRAM OF INDIANA.



HISTORICAL DIAGRAM OF ILLINOIS.

ILLINOIS.

Illinois Territory, originally part of the Northwest Territory, and subsequently a part of Indiana Territory, was organized on March 1, 1809. The following clause from the act separating it from Indiana Territory defines its boundary:

AN ACT for dividing the Indiana Territory into two separate governments.

From and after the first day of March next, all that part of the Indiana Territory which lies west of the Wabash River and a direct line drawn from the said Wabash River and Post Vincennes due north to the territory line between the United States and Canada shall, for the purpose of temporary government, constitute a separate Territory and be called Illinois. (Tenth Congress, second session.)

On December 3, 1818, it was admitted as a State, with its present boundaries. The enabling act defines these boundaries as follows:

AN ACT to enable the people of the Illinois Territory to form a constitution and State government, and for the admission of such State into the Union on an equal footing with the original States.

The said State shall consist of all the territory included within the following boundaries, to wit: Beginning at the mouth of the Wabash River; thence up the same and with the line of Indiana to the northwest corner of said State; thence east with the line of the same State to the middle of Lake Michigan; thence north along the middle of said lake to north latitude forty-two degrees thirty minutes; thence west to the middle of the Mississippi River; and thence down along the middle of that river to its confluence with the Ohio River; and thence up the latter river along its northwestern shore to the beginning. (Fifteenth Congress, second session.)

The northern boundary of Illinois was run and marked in 1832–33.

MICHIGAN.

Michigan was organized as a Territory June 30, 1805, from the northern part of Indiana Territory.

The following clause from the act dividing Indiana Territory defines its limits:

From and after the thirtieth day of June next all that part of the Indiana Territory which lies north of a line drawn east from the southerly bend or extreme of Lake Michigan, until it shall intersect Lake Erie, and east of a line drawn from the said southerly bend through the middle of said lake to its northern extremity, and thence due north to the northern boundary of the United States, shall, for the purpose of temporary government, constitute a separate Territory, and be called Michigan. (Eighth Congress, second session.)

This line was run and marked in 1827.

The enabling act for Illinois, passed in 1818, contained a provision transferring to the Territory of Michigan the portion of the Territory of Illinois not included in the State of that name. The following is the text of the clause referred to:

All that part of the territory of the United States lying north of the State of Indiana, and which was included in the former Indiana Territory, together with that part of the Illinois Territory which is situated north of and not included within the boundaries prescribed by this act, to the State thereby authorized to be formed, shall be, and hereby is, attached to and made a part of the Michigan Territory, from and after the formation of the said State.

In 1834 an act was passed extending the limits of the Territory of Michigan to the Missouri River.

The clause of this act relating to area is as follows:

AN ACT to attach the territory of the United States west of the Mississippi River and north of the State of Missouri to the Territory of Michigan.

All that part of the territory of the United States bounded on the east by the Mississippi River, on the south by the State of Missouri and a line drawn due west from the northwest corner of said State to the Missouri River; on the southwest and west by the Missouri River and the White Earth River, falling into the same; and on the north by the northern boundary of the United States, shall be, and hereby is, for the purpose of temporary government, attached to and made a part of the Territory of Michigan.

In 1836 Wisconsin Territory was formed from that part of Michigan Territory lying west of the present limits of the State of that name. (*Vide* Wisconsin, p. 121.)

The boundary line between Michigan and Wisconsin, between the sources of Brule and Montreal rivers, was run and marked in 1847.

Reduced to its present limits, as described in the following clause from its enabling act, Michigan was admitted to the Union January 26, 1837:

AN ACT to provide for the admission of the State of Michigan into the Union.

Beginning at the point where the above-described northern boundary of the State of Ohio intersects the eastern boundary of the State of Indiana, and running thence with the said boundary line of Ohio, as described in the first section of this act, until it intersects the boundary line between the United States and Canada in Lake Erie; thence with the said boundary line between the United States and Canada, through the Detroit River, Lake Huron, and Lake Superior, to a point where the said line last touches Lake Superior; thence in a direct line through Lake Superior to the mouth of the Montreal River; thence through the middle of the main channel of the said river Montreal to the middle of the Lake of the Desert; thence in a direct line to the nearest headwater of the Menomonee River; thence through the middle of that fork of the said river first touched by the said line to the main channel of the said Menomonee River; thence down the center of the main channel of the same to the center of the most usual ship channel of the Green Bay of Lake Michigan; thence through the center of the most usual ship channel of the said bay to the middle of Lake Michigan; thence through the middle of Lake Michigan to the northern boundary of the State of Indiana, as that line was established by the act of Congress of the nineteenth of April, eighteen hundred and sixteen; thence due east with the north boundary line of the said State of Indiana to the northeast corner thereof; and thence south with the east boundary line of Indiana to the place of beginning. (Twenty-fourth Congress, first session.)

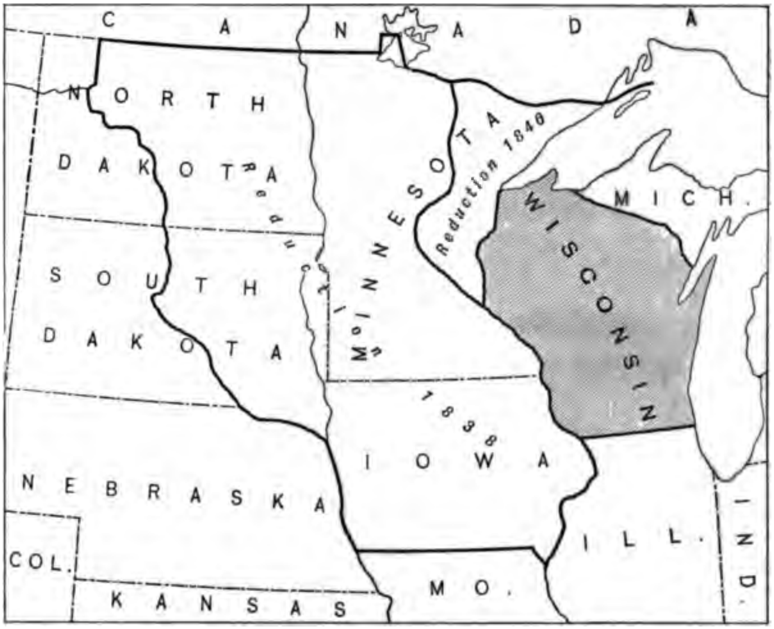
The above boundaries remain unchanged.

WISCONSIN.

Wisconsin was organized as a Territory July 3, 1836. As originally constituted its area comprised all that part of the former Territory of Michigan which lay outside of the present limits of the State of Michigan. The limits are defined in the act for its organization as follows:

Bounded on the east by a line drawn from the northeast corner of the State of Illinois, through the middle of Lake Michigan, to a point in the middle of said lake and opposite the main channel of Green Bay, and through said channel and Green Bay to

HISTORICAL DIAGRAM OF MICHIGAN.



HISTORICAL DIAGRAM OF WISCONSIN.

the mouth of the Menomonee; thence through the middle of the main channel of said river to that head of said river nearest to the Lake of the Desert; thence in a direct line to the middle of said lake; thence through the middle of the main channel of the Montreal River to its mouth; thence with a direct line across Lake Superior to where the territorial line of the United States last touches said lake northwest; thence on the north with the said territorial line to the White Earth River, on the west by a line from the said boundary line following down the middle of the main channel of White Earth River to the Missouri River, and down the middle of the main channel of the Missouri River to a point due west from the northwest corner of the State of Missouri, and on the south from said point due east to the northwest corner of the State of Missouri; and thence with the boundaries of the States of Missouri and Illinois as already fixed by acts of Congress. (Twenty-fourth Congress, first session.)

In 1838 all that part of the territory lying west of the Mississippi and a line drawn due north from its source to the international boundary—that is, all that part which was originally comprised in the Louisiana purchase—was organized as the Territory of Iowa. (See Iowa, p. 123.)

On August 9, 1846, an enabling act for Wisconsin was passed giving the boundaries as follows:

Beginning at the northeast corner of the State of Illinois, that is to say, at a point in the center of Lake Michigan where the line of forty-two degrees and thirty minutes of north latitude crosses the same; thence running with the boundary line of the State of Michigan, through Lake Michigan, Green Bay, to the mouth of the Menomonee River; thence up the channel of said river to the Brule River; thence up said last-mentioned river to Lake Brule; thence along the southern shore of Lake Brule in a direct line to the center of the channel between Middle and South islands in the Lake of the Desert; thence in a direct line to the headwaters of Montreal River, as marked upon the survey made by Captain Cramm; thence down the main channel of the Montreal River to the middle of Lake Superior; thence through the center of Lake Superior to the mouth of the Saint Louis River; thence up the main channel of said river to the first rapids in the same, above the Indian village, according to Nicollet's map; thence due south to the main branch of the river Saint Croix; thence down the middle of the main channel of said river to the Mississippi; thence down the center of the main channel of that river to the northwest corner of the State of Illinois; thence due east with the northern boundary of the State of Illinois to the place of beginning. (Twenty-ninth Congress, first session.)

On March 3, 1847, a supplementary act for the admission of Wisconsin was passed by Congress, in which the western boundary of the proposed State was changed as follows:

That the assent of Congress is hereby given to the change of boundary proposed in the first article of said constitution, to wit: Leaving the boundary line prescribed in the act of Congress entitled "An act to enable the people of Wisconsin Territory to form a constitution and State government, and for the admission of such State into the Union," at the first rapids in the river St. Louis; thence in a direct line southwardly to a point fifteen miles east of the most easterly point of Lake St. Croix; thence due south to the main channel of the Mississippi River or Lake Pepin; thence down the said main channel, as prescribed in said act. (Twenty-ninth Congress, second section.)

On May 29, 1848, Wisconsin was admitted into the Union.

The boundary between this State and Minnesota from St. Louis to St. Croix River was surveyed and marked in 1852, under the General Land Office.

MISSOURI.

The name of the Territory of Louisiana was changed in 1812 to Missouri, by act of Congress. At that time the Territory comprised all of the original Louisiana purchase, excepting the State of Louisiana, which had been formed from it. The Territory of Arkansas, with limits very similar to those of the present State, was formed from it in 1819. On August 10, 1821, the *State* of Missouri was formed and admitted, with limits, excepting as to the northwest corner, the same as at present.

Boundaries are defined as follows:

> Beginning in the middle of the Mississippi River, on the parallel of thirty-six degrees of north latitude; thence west along that parallel of latitude to the Saint Francois River; thence up and following the course of that river, in the middle of the main channel thereof, to the parallel of latitude of thirty-six degrees and thirty minutes; thence west along the same to a point where the said parallel is intersected by a meridian line passing through the middle of the mouth of the Kansas River where the same empties into the Missouri River; thence from the point aforesaid north along the said meridian line to the intersection of the parallel of latitude which passes through the rapids of the river Des Moines, making the said line to correspond with the Indian boundary line; thence east from the point of intersection last aforesaid along the said parallel of latitude to the middle of the channel of the main fork of the said river Des Moines; thence down and along the middle of the main channel of the said river Des Moines to the mouth of the same where it empties into the Mississippi River; thence due east to the middle of the main channel of the Mississippi River; thence down and following the course of the Mississippi River, in the middle of the main channel thereof, to the place of beginning. (Sixteenth Congress, first session.)

In 1836 the boundaries were extended on the northwest to the Missouri River, as described in the following act of the legislature amendatory to the constitution of 1820:

> That the boundary of the State be so altered and extended as to include all that tract of land lying on the north side of the Missouri River and west of the present boundary of this State, so that the same shall be bounded on the south by the middle of the main channel of the Missouri River and on the north by the present northern boundary line of the State, as established by the constitution, when the same is continued in a right line to the west, or to include so much of said tract of land as Congress may assent.

This was ratified by Congress in the following act:

> AN ACT to extend the western boundary of the State of Missouri to the Missouri River.
>
> That when the Indian title to all the lands lying between the State of Missouri and the Missouri River shall be extinguished, the jurisdiction over said lands shall be hereby ceded to the State of Missouri, and the western boundary of said State shall be then extended to the Missouri River. (Twenty-fourth Congress, first session.)

The north boundary of Missouri was surveyed and marked in part in 1816, and the remainder in 1850, under the General Land Office.

The western boundary was run and marked, from the mouth of Kansas River to the southwestern corner of the State, in 1823.

The territory remaining after the formation of the State bore the name of Missouri for many years thereafter. Meanwhile, however, it

HISTORICAL DIAGRAM OF MISSOURI.

was reduced by the formation of several Territories which were carved from its area. In 1834 the part north of the State of Missouri and east of Missouri and White Earth rivers was annexed to the Territory of Michigan. (For further history of this portion, *vide* Michigan, p. 119; Iowa, below; Minnesota, p. 124; and Dakota, p. 127.) In 1854 Kansas and Nebraska Territories were formed, absorbing the remainder. (*Vide* Kansas, p. 125, and Nebraska, p. 126.)

The following are the boundaries of Missouri as at present established: The east boundary is the mid-channel of the Mississippi River from the mouth of the Des Moines to its point of intersection with the thirty-sixth parallel of latitude; the south boundary begins at the latter point and runs west on the parallel of 36 degrees of latitude to the Saint Francis River, thence up the mid-channel of that river to the parallel of latitude 39° 30′, thence west on that parallel to its intersection by a meridian passing through the middle of the mouth of the Kansas River; the west boundary is the last-mentioned meridian as far north as the mouth of the Kansas River, thence it follows northwestward the mid-channel of the Missouri River to the parallel of latitude passing through the rapids of Des Moines River, which is approximately the parallel of 40° 35′; the north boundary is the last-mentioned parallel as far east as its point of intersection with the Des Moines River, whence it follows the mid-channel of the Des Moines River southward to its mouth.

IOWA.

Iowa was organized as a Territory on July 3, 1838, being formed from a portion of Wisconsin Territory. The limits were defined as follows in the act creating it:

> All that part of the present Territory of Wisconsin which lies west of the Mississippi River and west of the line drawn due north from the headwaters or sources of the Mississippi to the Territorial line. (Twenty-fifth Congress, second session. See Wisconsin, p. 115.)

The following clause from an act passed in 1839 is supplementary to the above act:

> AN ACT to define and establish the eastern boundary line of the Territory of Iowa.
>
> That the middle or centre of the main channel of the river Mississippi shall be deemed, and is hereby declared, to be the eastern boundary line of the Territory of Iowa, so far or to such extent as the said Territory is bounded eastwardly by or upon said river. (Twenty-fifth Congress, third session.)

Iowa was admitted to the Union on March 3, 1845. As originally constituted the limits of the State were quite different from those which it has at present.

The following extract from the enabling act gives the original limits:

> That the following shall be the boundaries of the said State of Iowa, to wit: Beginning at the mouth of the Des Moines River at the middle of the Mississippi; thence by the middle of the channel of that river to a parallel of latitude passing through the mouth of the Mankato, or Blue Earth River; thence west along the

said parallel of latitude to a point where it is intersected by a meridian line, se teen degrees and thirty minutes west of the meridian of Washington City; th due south to the northern boundary line of the State of Missouri; thence eastwa following that boundary to the point at which the same intersects the Des Mo River; thence by the middle of the channel of that river to the place of begin (Twenty-eighth Congress, second session.)

On December 28, 1846, an act was passed changing the bounda of the State and giving it its present limits.

The following extract from the act defines the boundaries as at p ent constituted:

Beginning in the middle of the main channel of the Mississippi River, at a p due east of the middle of the mouth of the main channel of the Des Moines Ri thence up the middle of the main channel of the said Des Moines River to a p on said river where the northern boundary line of the State of Missouri, as es lished by the constitution of that State, adopted June twelfth, eighteen hun and twenty, crosses the said middle of the main channel of the said Des Mo River; thence westwardly along the said northern boundary line of the State of souri, as established at the time aforesaid, until an extension of said line inte the middle of the main channel of the Missouri River, to a point opposite the mi of the main channel of the Big Sioux River, according to Nicollet's map; theno the main channel of the said Big Sioux River, according to said map, until intersected by the parallel of forty-three degrees and thirty minutes north latit thence east along said parallel of forty-three degrees and thirty minutes, until parallel intersect the middle of the main channel of the Mississippi River; th down the middle of the main channel of said Mississippi River to the plac beginning.

Its northern boundary was surveyed and marked in 1852, under General Land Office.

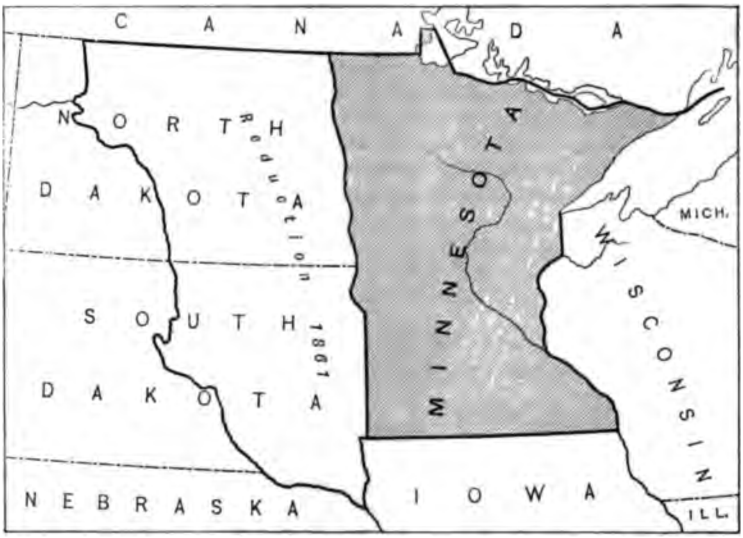
MINNESOTA.

The Territory of Minnesota was organized on March 3, 1849, originally comprised the portion of the former Territory of Iowa, side of the limits of the present State of Iowa, extending east to west boundary line of Wisconsin. The terms of the act creating Territory, so far as they relate to its boundary, are as follows:

All that part of the territory of the United States which lies within the follow limits, to wit: Beginning in the Mississippi River, at the point where the lin forty-three degrees and thirty minutes of north latitude crosses the same; th running due west on said line, which is the northern boundary of the State of Io to the northwest corner of the said State of Iowa; thence southerly along the w ern boundary of said State to the point where said boundary strikes the Miss River; thence up the middle of the main channel of the Missouri River to the mo of the White Earth River; thence up the middle of the main channel of the W Earth River to the boundary line between the possessions of the United States Great Britain to Lake Superior; thence along the western boundary line of said S of Wisconsin to the Mississippi River; thence down the main channel of said rive the place of beginning. (Thirtieth Congress, second session.)

Minnesota was admitted as a State on May 11, 1858, with the sa boundaries which it has at present. These are given in the enabl act as follows:

Beginning at the point in the center of the main channel of the Red River of *North* where the boundary line between the United States and the British Possess



HISTORICAL DIAGRAM OF MINNESOTA.

HISTORICAL DIAGRAM OF IOWA.

crosses the same; thence up the main channel of said river to that of the Bois des Sioux River; thence up the main channel of said river to Lake Traverse; thence up the center of said lake to the southern extremity thereof; thence in a direct line to the head of Big Stone Lake; thence through its center to its outlet; thence by a due south line to the north line of the State of Iowa; thence east along the northern boundary of said State to the main channel of the Mississippi River; thence up the main channel of said river, and following the boundary line of the State of Wisconsin until the same intersects the Saint Louis River; thence down said river to and through Lake Superior, on the boundary line of Wisconsin and Michigan, until it intersects the dividing line between the United States and the British Possessions; thence up Pigeon River, and following said dividing line, to the place of beginning.

The western boundary line, from Big Sioux River to Minnesota River, was surveyed and marked in 1859–60, under the General Land Office.

KANSAS.

The Territory of Kansas was organized on May 30, 1854, from a part of Missouri Territory. The following clause from the act of organization defines its limits:

SECTION 19. All that part of the territory of the United States included within the following limits, except such portions thereof as are hereinafter expressly exempted from the operations of this act, to wit: Beginning at a point on the western boundary of the State of Missouri, where the thirty-seventh parallel of north latitude crosses the same; thence west on said parallel to the eastern boundary of New Mexico; thence north on said boundary to latitude thirty-eight; thence following said boundary westward to the east boundary of the Territory of Utah, on the summit of the Rocky Mountains; thence northward on said summit to the fortieth parallel of latitude; thence east on said parallel to the western boundary of the State of Missouri; thence south with the western boundary of said State to the place of beginning, be, and the same is hereby, created into a temporary government by the name of the Territory of Kansas.

A portion of this Territory was given up to Colorado at the time of its formation in 1861. (*Vide* Colorado, p. 130.)

Kansas was admitted into the Union on January 29, 1861, with its present boundaries, which are thus defined in the enabling act:

The said State shall consist of all the territory included within the following boundaries, to wit: Beginning at a point on the western boundary of the State of Missouri where the thirty-seventh parallel of north latitude crosses the same; thence west on said parallel to the twenty-fifth meridian of longitude west from Washington; thence north on said meridian to the fortieth parallel of latitude; thence east on said parallel to the western boundary of the State of Missouri; thence south with the western boundary of said State to the place of beginning.

The south boundary was surveyed and marked by Col. J. E. Johnston, in 1857. This line was subsequently retraced and re-marked by deputy surveyors, in the extension of the public land surveys. The western boundary was surveyed in 1872, under the General Land Office.

The north boundary, which is the base line for the sixth principal meridian, was run by deputy surveyors of the General Land Office, 1855–59, the initial point, on the Missouri river, having been determined by Capt. Lee, U. S. topographical engineer.

NEBRASKA.

The Territory of Nebraska was formed on May 30, 1854, from the northwestern part of Missouri Territory. Its limits, as originally constituted, are defined as follows in the act of organization:

> Beginning at a point in the Missouri River where the fortieth parallel of north latitude crosses the same; thence west on said parallel to the east boundary of the Territory of Utah, on the summit of the Rocky Mountains; thence on said summit northward to the forty-ninth parallel of north latitude; thence east on said parallel to the western boundary of the Territory of Minnesota; thence southward on said boundary to the Missouri River; thence down the main channel of said river to the place of beginning, be, and the same is hereby, created into a temporary government by the name of the Territory of Nebraska. (Thirty-third Congress, first session.)

This area was reduced in 1861 by the formation of the Territories of Colorado and Dakota. (*Vide* Colorado, p. 130, and Dakota, p. 127.)

The State of Nebraska was admitted on March 1, 1867.

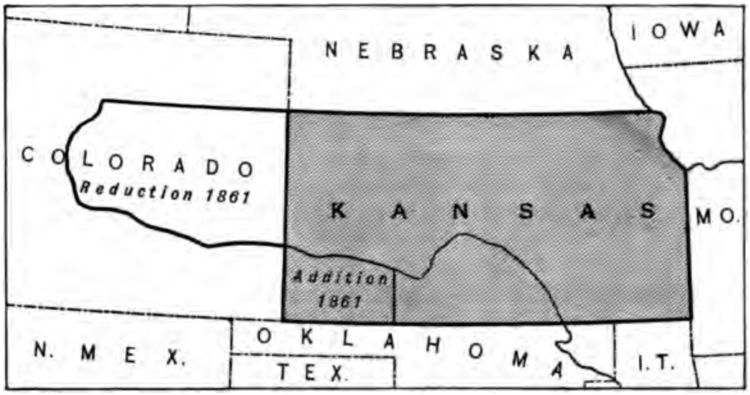
Its limits are defined as follows in the enabling act:

> That the said State of Nebraska shall consist of all the territory included within the following boundaries, to wit: Commencing at a point formed by the intersection of the western boundary of the State of Missouri with the fortieth degree of north latitude; extending thence due west along said fortieth degree of north latitude to a point formed by its intersection with the twenty-fifth degree of longitude west from Washington; thence north along said twenty-fifth degree of longitude to a point formed by its intersection with the forty-first degree of north latitude; thence west along said forty-first degree of north latitude to a point formed by its intersection with the twenty-seventh degree of longitude west from Washington; thence north along said twenty-seventh degree of west longitude to a point formed by its intersection with the forty-third degree of north latitude; thence east along said forty-third degree of north latitude to the Keyapaha River; thence down the middle of the channel of said river, with its meanderings, to its junction with the Niobrara River; thence down the middle of the channel of said Niobrara River, and following the meanderings thereof, to its junction with the Missouri River; thence down the middle of the channel of said Missouri River, and following the meanderings thereof, to the place of beginning. (Thirty-eighth Congress, first session.)

In 1870 an act was passed to redefine a portion of the boundary between Nebraska and the Territory of Dakota, the pertinent portion of which is as follows:

> That so soon as the State of Nebraska, through her legislature, has given her consent thereto, the center of the main channel of the Missouri River shall be the boundary line between the State of Nebraska and Territory of Dakota, between the following points, to wit: Commencing at a point in the center of said main channel, north of the west line of section twenty-four in township twenty-nine north, of range eight east of the sixth principal meridian, and running along the same to a point west of the most northerly portion of fractional section seventeen, of township twenty-nine north, of range nine east of said meridian, in the State of Nebraska, as meandered and shown by the plats and surveys of said sections originally made and now on file in the General Land Office. (Forty-first Congress, second session.)

The west boundary on the twenty-fifth degree of longitude west of Washington, between latitudes 40° and 41°, the south boundary on the forty-first parallel from the twenty-fifth degree of longitude to the



HISTORICAL DIAGRAM OF KANSAS.

HISTORICAL DIAGRAM OF NEBRASKA.

twenty-seventh degree, and the west boundary on the twenty-seventh degree of longitude, between the forty-first degree and the forty-third degree, were surveyed and marked in 1869, under the General Land Office.

In 1882 an act was passed transferring to this State from Dakota a small area lying between the Keyapaha River and the forty-third parallel of latitude. The following is the act in question:

> *Be it enacted,* * * * That the northern boundary of the State of Nebraska shall be, and hereby is, subject to the provisions hereinafter contained, extended so as to include all that portion of the Territory of Dakota lying south of the forty-third parallel of north latitude and east of the Keyapaha River and west of the main channel of the Missouri River. (Forty-seventh Congress, first session.)

The north boundary, from the Keyapaha River westward, was surveyed in 1873. In 1893 the part of this boundary east of Keyapaha River was surveyed and the remainder resurveyed. All this was done under the General Land Office.

NORTH DAKOTA AND SOUTH DAKOTA.

The Territory of Dakota was organized on March 2, 1861, from parts of Minnesota and Nebraska Territories. The following from the act of organization defines its original limits:

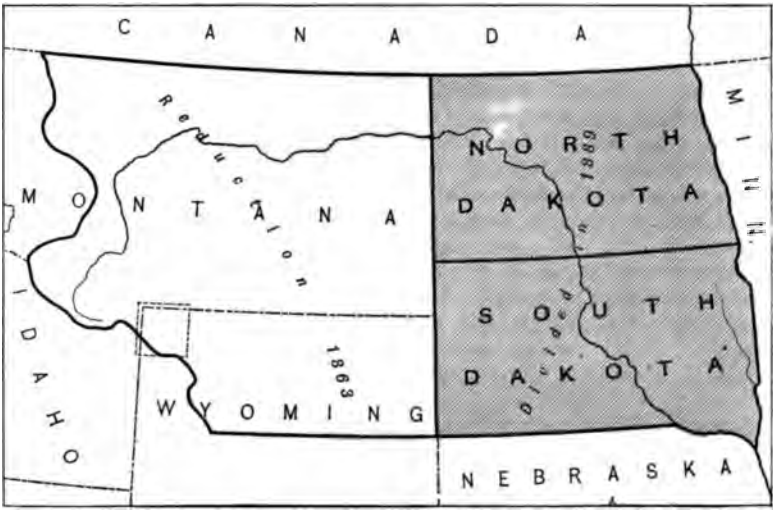
> All that part of the territory of the United States included within the following limits, namely: Commencing at a point in the main channel of the Red River of the North where the forty-ninth degree of north latitude crosses the same; thence up the main channel of the same and along the boundary of the State of Minnesota to Big Stone Lake; thence along the boundary line of the said State of Minnesota to the Iowa line; thence along the boundary line of the State of Iowa to the point of intersection between the Big Sioux and Missouri rivers; thence up the Missouri River and along the boundary line of the Territory of Nebraska to the mouth of the Niobrara or Running Water River; thence following up the same, in the middle of the main channel thereof, to the mouth of the Keyapaha or Turtle Hill River; thence up said river to the forty-third parallel of north latitude; thence due west to the present boundary of the Territory of Washington; thence along the boundary line of Washington Territory to the forty-ninth degree of north latitude; thence east along said forty-ninth degree of north latitude to the place of beginning, be, and the same is hereby, organized into a temporary government by the name of the Territory of Dakota. (Thirty-sixth Congress, second session.)

In 1863 the Territory of Idaho was formed, its area having been taken from Washington, Dakota, and Nebraska. (*Vide* Idaho, p. 134.) In 1882 a small area was transferred to Nebraska. (*Vide* Nebraska, above.)

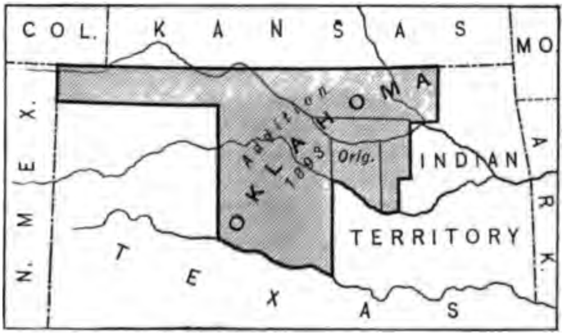
In 1877 that part of the west boundary between latitudes 43° and 45° was surveyed and marked, under the General Land Office.

On November 2, 1889, the Territory of Dakota was divided into North and South Dakota, and each was admitted as a State. The following extract from the enabling act defines the boundary between these States:

> The area comprising the Territory of Dakota shall * * * be divided on the line of the seventh standard parallel produced due west to the western boundary of said Territory.



HISTORICAL DIAGRAM OF NORTH DAKOTA AND SOUTH DAKOTA.



HISTORICAL DIAGRAM OF OKLAHOMA.

MONTANA.

The Territory of Montana was organized May 26, 1864, from a portion of Idaho. Its limits, which have been changed but slightly, are given in the following extract from the organizing act:

> That all that part of the territory of the United States included within the limits to wit: Commencing at a point formed by the intersection of the twenty-seventh degree of longitude west from Washington with the forty-fifth degree of north latitude; thence due west on said forty-fifth degree of latitude to a point formed by its intersection with the thirty-fourth degree of longitude west from Washington; thence due south along said thirty-fourth degree of longitude to its intersection with the forty-fourth degree and thirty minutes of north latitude; thence due west along said forty-fourth degree and thirty minutes of north latitude to a point formed by its intersection with the crest of the Rocky Mountains; thence following the crest of the Rocky Mountains northward till its intersection with the Bitter Root Mountains; thence northward along the crest of said Bitter Root Mountains to its intersection with the thirty-ninth degree of longitude west from Washington; thence along said thirty-ninth degree of longitude northward to the boundary line of the British possessions; thence eastward along said boundary line to the twenty-seventh degree of longitude west from Washington; thence southward along said twenty-seventh degree of longitude to the place of beginning, be, and the same is hereby, created into a temporary government by the name of the Territory of Montana. (Thirty-eighth Congress, first session.)

In 1873 Congress, under the erroneous impression that a portion of Dakota remained west of Wyoming, and adjoining Montana, passed an act to attach it to Montana. As, however, no such detached area could by any possibility have existed, the compilers of the Revised Statutes sought to give the act effect by shifting a portion of the southern boundary of Montana from the parallel of 44° 30′ to the continental watershed, thereby reducing Montana's area. The following is the act referred to:

> AN ACT to readjust the western boundary of Dakota Territory.
>
> That all that portion of Dakota Territory lying west of the one hundred and eleventh meridian of longitude which, by an erroneous definition of the boundaries of said Territory by a former act of Congress, remains detached and distant from Dakota proper some two hundred miles, be, and the same is hereby, attached to the adjoining territory of Montana. (Forty-second Congress, third session.)

The boundaries of Montana are as follows: Beginning at the intersection of the twenty-seventh meridian of longitude with the boundary line between the United States and the British possessions, it follows said meridian south to the forty-fifth parallel of latitude, thence west on this parallel to the thirty-fourth meridian, south on the thirty-fourth meridian to the point where that meridian intersects the continental watershed, thence westward and northwestward, following the line of the continental watershed and the summit of the Bitter Root range, to its intersection with the thirty-ninth meridian; thence north on the thirty-ninth meridian to the boundary line between the United States and British possessions and east on that boundary line to the point of beginning.

The east boundary of Montana was surveyed and marked in 1885, and the south boundary in 1879–80, under the General Land Office. That portion of the west boundary between the crest of the Bitterroot Mountains and the Canada line was surveyed and marked in 1898–99, under the United States Geological Survey.

Montana was admitted as a State on November 8, 1889, with the above boundaries.

WYOMING.

Wyoming was organized as a Territory on July 25, 1868, from an area previously comprised in the Territory of Idaho. Its limits, which are the same as originally constituted, are defined in the following clause from the act creating the Territory:

> That all that part of the United States described as follows: Commencing at the intersection of the twenty-seventh meridian of longitude west from Washington with the forty-fifth degree of north latitude, and running thence west to the thirty-fourth meridian of west longitude, thence south to the forty-first degree of north latitude, thence east to the twenty-seventh meridian of west longitude, and thence north to the place of beginning, be, and the same is hereby, organized into a temporary government by the name of the Territory of Wyoming. (Fortieth Congress, second session.)

Wyoming was admitted as a State on July 10, 1890, with the above boundaries.

The south and west boundaries were surveyed and marked in 1873, under the General Land Office.

COLORADO.

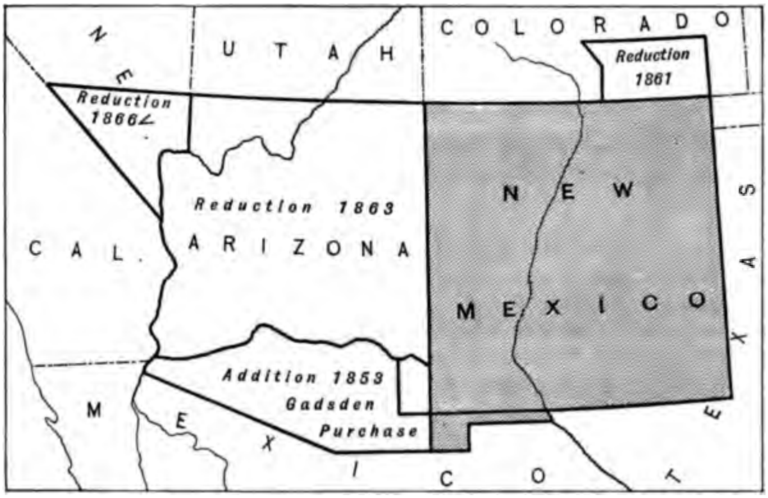
Colorado was organized as a Territory on February 28, 1861, with the limits which it has at present, being made from portions of Utah, New Mexico, Kansas, and Nebraska.

On August 1, 1876, it was admitted as a State.

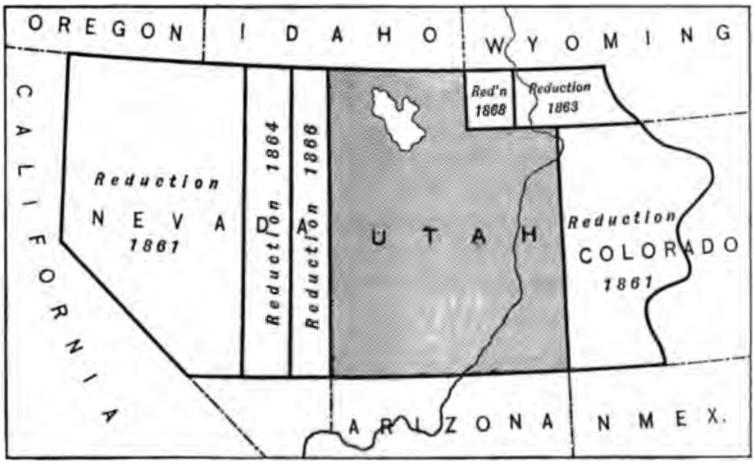
The following clause from the enabling act gives its limits:

> AN ACT to enable the people of Colorado to form a constitution and State government, and for the admission of such State into the Union on an equal footing with the original States.
>
> SEC. 2. That the said State of Colorado shall consist of all the territory included within the following boundaries, to-wit: Commencing at a point formed by the intersection of the thirty-seventh degree of north latitude with the twenty-fifth degree of longitude west from Washington; extending thence due west along said thirty-seventh degree of north latitude to a point formed by its intersection with the thirty-second degree of longitude west from Washington; thence due north along said thirty-second degree of west longitude to a point formed by its intersection with the forty-first degree of north latitude; thence due east along said forty-first degree of north latitude to a point formed by its intersection with the twenty-fifth degree of longitude west from Washington; thence due south along said twenty-fifth degree of west longitude. (Thirty-eighth Congress, first session.)

The south boundary of Colorado was run and marked in 1868 and 1874, and the west boundary in 1878–79. The latter line was retraced and re-marked in 1885. All this was under the General Land Office.



HISTORICAL DIAGRAM OF NEW MEXICO.



HISTORICAL DIAGRAM OF UTAH.

NEW MEXICO.

New Mexico was organized as a Territory on December 13, 1850. Its original area formed a part of the region transferred by Mexico to the United States by the treaty of Guadalupe-Hidalgo and by Texas. It was subsequently enlarged by the Gadsden Purchase. The formation of Colorado Territory in 1861 and of Arizona in 1863 reduced its area to its present limits. (*Vide* Colorado, p. 130, and Arizona, p. 132.)

The following clause from the act creating the Territory gives its original limits:

> SECTION 2. And be it further enacted, That all that portion of the territory of the United States bounded as follows: Beginning at a point in the Colorado River, where the boundary line with the Republic of Mexico crosses the same; thence eastwardly with the said boundary line to the Rio Grande; thence following the main channel of said river to the parallel of the thirty-second degree of north latitude; thence east with said degree to its intersection with the one hundred and third degree of longitude west of Greenwich; thence north with said degree of longitude to the parallel of thirty-eighth degree of north latitude; thence west with said parallel to the summit of the Sierra Madre; thence south with the crest of said mountains to the thirty-seventh parallel of north latitude; thence west with said parallel to its intersection with the boundary line of the State of California; thence with said boundary line to the place of beginning—be, and the same is hereby, erected into a temporary government by the name of the Territory of New Mexico. (Thirty-first Congress, first session.)

The present boundaries of New Mexico are as follows: Beginning at the point of intersection of the one hundred and third meridian of longitude west of Greenwich with the thirty-seventh parallel of latitude; running thence south to its point of intersection with the thirty-second parallel of latitude; thence west on this parallel to its intersection with the Rio Grande; thence southerly down the main channel of the Rio Grande to its point of intersection with the boundary line between the United States and Mexico; thence with this boundary to its intersection with the thirty-second meridian of longitude; thence north along this meridian to the thirty-seventh parallel of latitude, and so along that parallel to the point of beginning.

The west boundary of New Mexico was run and marked in 1875, under the General Land Office.

UTAH.

Utah was organized on September 9, 1850, from territory acquired from Mexico by the treaty of Guadalupe-Hidalgo. Its limits originally extended from the eastern boundary of California to the Rocky Mountains, and from the thirty-seventh to the forty-second parallel. This area was reduced by the formation, in 1861, of the Territories of Nevada (*vide* p. 132) and Colorado (*see* p. 130), and in 1864 and 1866 by the extension eastward of the limits of the State of Nevada (*vide* p. 133).

The following is an extract from the act creating the Territory.

> All that part of the territory of the United States included within the following limits, to wit: Bounded on the west by the State of California, on the north by the Territory of Oregon, and on the east by the summit of the Rocky Mountains, and on the south by the thirty-seventh parallel of north latitude, be, and the same is hereby, created into a temporary government, by the name of the Territory of Utah.

The present boundaries of Utah are as follows: Commencing with the intersection of the forty-second parallel of latitude with the thirty-fourth meridian of longitude; running thence south on this meridian to the forty-first parallel of latitude; thence east on this parallel to the thirty-second meridian of longitude; thence south on this meridian to its intersection with the thirty-seventh parallel of latitude; thence west upon this parallel of latitude to its intersection with the thirty-seventh meridian of longitude; thence north on this meridian to its intersection with the forty-seventh parallel of latitude; thence east on the forty-seventh parallel of latitude to the point of beginning.

Utah was admitted as a State on January 4, 1896, with the above boundaries.

Its north boundary, from longitude 34° to 37°, was surveyed and marked in 1871, and its west boundary in 1870, under the General Land Office.

ARIZONA.

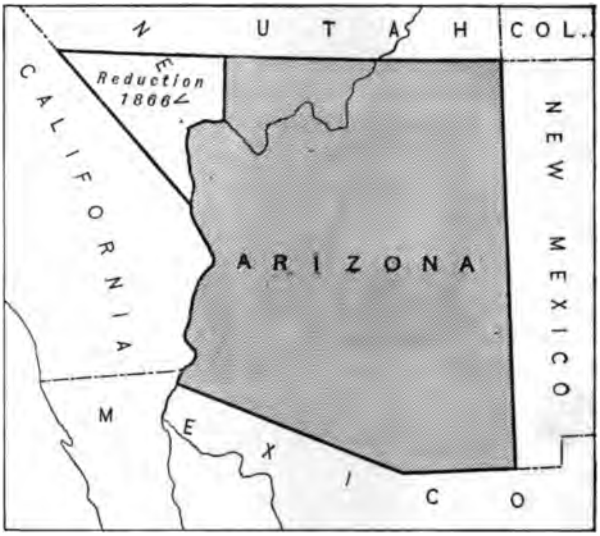
Arizona was organized as a Territory on February 24, 1863. Its area was formerly comprised in the Territory of New Mexico. In 1866 a portion of it was cut off and given to the State of Nevada. (*Vide* Nevada, below.) The following clause from the act creating it gives its limits as originally constituted:

> That all that part of the present Territory of New Mexico situate west of the line running due south from the point where the southwest corner of the Territory of Colorado joins the northern boundary of the Territory of New Mexico to the southern boundary line of said Territory of New Mexico be, and the same is hereby, erected into a temporary government by the name of the Territory of Arizona. (For limits of the piece cut off and added to Nevada, see that State.)

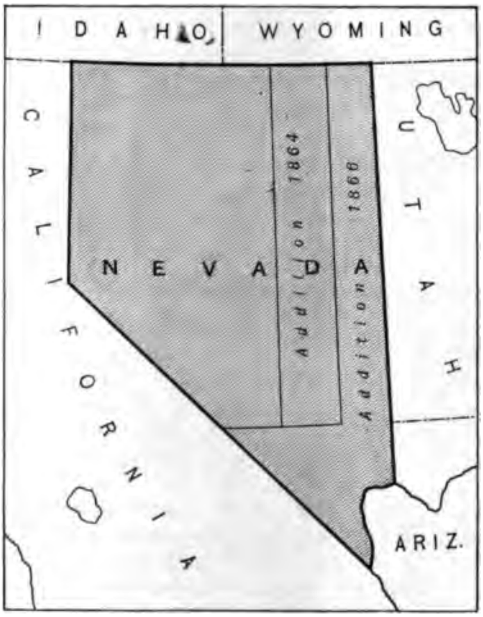
The present boundaries of Arizona are as follows: Beginning at the point of intersection of the thirty-seventh parallel of latitude with the thirty-second meridian of longitude; thence south along this meridian to its intersection with the boundary line between the United States and Mexico; thence with this boundary to the Colorado River; thence up the middle of the main channel of the Colorado River to its point of intersection with the thirty-seventh meridian of longitude; north on this meridian to its intersection with the thirty-seventh parallel; and eastward along the thirty-seventh parallel to the point of beginning.

NEVADA.

Nevada, as originally constituted on March 2, 1861, was formed from territory taken from Utah. Its western boundary was made to conform to the eastern boundary of California (*vide* California, p. 136); its north-



HISTORICAL DIAGRAM OF ARIZONA.



HISTORICAL DIAGRAM OF NEVADA.

ern boundary was, as now, the forty-second parallel; the eastern was the meridian of 39°, and the southern the parallel of 37°. By the enabling act the eastern limit was extended to the thirty-eighth meridian. It was admitted as a State October 31, 1864, with above limits as modified by the enabling act, and in 1866 its eastern limits were still further extended to longitude 37°, and its southern line established as at present, the latter addition having been made from Arizona.

In the act organizing the Territory the boundaries are defined as follows:

Beginning at the point of intersection of the forty-second degree of north latitude with the thirty-ninth degree of longitude west from Washington; thence running south on the line of said thirty-ninth degree of west longitude until it intersects the northern boundary line of the Territory of New Mexico; thence due west to the dividing ridge separating the waters of Carson Valley from those that flow into the Pacific; thence on said dividing ridge northwardly to the forty-first degree of north latitude; thence due north to the southern boundary of the State of Oregon; thence due east to the place of beginning. (Thirty-sixth Congress, second session.)

The following is the text of that portion of the enabling act relating to boundaries:

SEC. 2. That the said State of Nevada shall consist of all the territory included within the following boundaries, to wit: Commencing at a point formed by the intersection of the thirty-eighth degree of longitude west from Washington with the thirty-seventh degree of north latitude; thence due west along said thirty-seventh degree of north latitude to the eastern boundary line of the State of California; thence in a northwesterly direction along the said eastern boundary line of the State of California to the forty-third degree of longitude west from Washington; thence north along said forty-third degree of west longitude and said eastern boundary line of the State of California to the forty-second degree of north latitude; thence due east along the said forty-second degree of north latitude to a point formed by its intersection with the aforesaid thirty-eighth degree of longitude west from Washington; thence due south down said thirty-eighth degree of west longitude to the place of beginning. (Thirty-eighth Congress, first session.)

The following act makes the addition to its area from Arizona referred to above:

AN ACT concerning the boundaries of the State of Nevada.

That, as provided for and consented to in the constitution of the State of Nevada, all that territory and tract of land adjoining the present eastern boundary of the State of Nevada, and lying between the thirty-seventh and the forty-second degrees of north latitude and west of the thirty-seventh degree of longitude west of Washington, is hereby added to and made a part of the State of Nevada.

SEC. 2. That there is hereby added to and made a part of the State of Nevada all that extent of territory lying within the following boundaries, to wit: Commencing on the thirty-seventh degree of north latitude at the thirty-seventh degree of longitude west from Washington, and running thence south on said degree of longitude to the middle of the river Colorado of the West; thence down the middle of said river to the eastern boundary of the State of California; thence northwesterly along said boundary of California to the thirty-seventh degree of north latitude; and thence east along said degree of latitude to the point of beginning. (Thirty-ninth Congress, first session.)

The present limits of Nevada are as follows:

The east boundary is the thirty-seventh meridian of longitude, extending from the forty-second parallel of latitude southward to its intersection with the middle of the Colorado River; thence following the mid-channel of the Colorado River down to the point where it intersects the thirty-fifth parallel of latitude; the southwest boundary is the arc of a great circle running from the last-mentioned point and the point of intersection of the one hundred and twentieth degree of longitude west of Greenwich with the thirty-ninth parallel of latitude; the west boundary is the one hundred and twentieth degree of longitude west of Greenwich; the north boundary is the forty-second parallel of latitude.

The north boundary was surveyed and marked in 1873, and the west boundary, from latitude 42° south to Lake Tahoe and thence southeast to Colorado River, in latitude 35°, in 1872, under the General Land Office. Between 1890 and 1899 the United States Coast and Geodetic Survey, under an appropriation by Congress, ran a new line from Lake Tahoe to Colorado River, differing widely in some places from the former line. At this writing this line has not yet been accepted as the boundary.

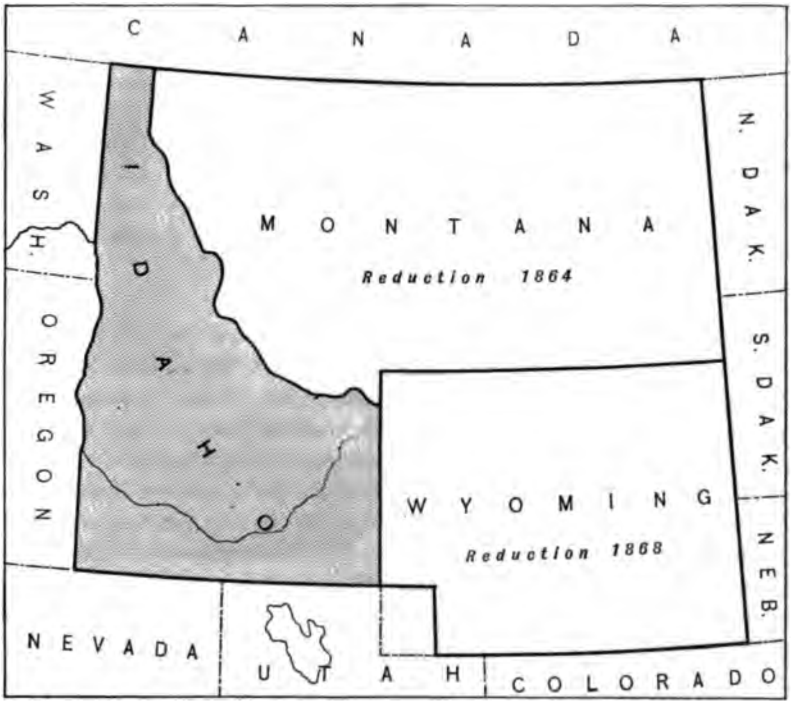
IDAHO.

The Territory of Idaho was formed March 3, 1863, from parts of Washington, Dakota, and Nebraska. Its original limits, which included, besides the present territory, all of Montana and Wyoming, were given as follows in the act organizing the Territory:

> That all that part of the territory of the United States included within the following limits, to wit: Beginning at a point in the middle channel of the Snake River where the northern boundary of Oregon intersects the same; then follow down said channel of Snake River to a point opposite the mouth of the Kooskooskia, or Clearwater River; thence due north to the forty-ninth parallel of latitude; thence east along said parallel to the twenty-seventh degree of longitude west of Washington; thence south along said degree of longitude to the northern boundary of Colorado Territory; thence west along said boundary to the thirty-third degree of longitude west of Washington; thence north along said degree to the forty-second parallel of latitude; thence west along said parallel to the eastern boundary of the State of Oregon; thence north along said boundary to the place of beginning. (Thirty-seventh Congress, third session.)

From this were formed Montana in 1864 (*vide* Montana, p. 129), and Wyoming (*vide* Wyoming, p. 130), in 1868, thereby reducing this territory, with the small addition made in 1873 (*vide* Montana, p. 129), to its present limits.

The present boundary line of Idaho is as follows: Beginning at the intersection of the thirty-ninth meridian with the boundary line between the United States and the British Possessions, it follows said meridian south until it reaches the summit of the Bitter Root Mountains; thence southeastward along the crest of the Bitter Root range and the continental divide until it intersects the meridian of thirty-four degrees of longitude; thence southward on this meridian to the forty-second parallel



HISTORICAL DIAGRAM OF IDAHO.

of latitude; thence west on this parallel of latitude to its intersection with a meridian drawn through the mouth of the Owyhee River; north on this meridian to the mouth of the Owyhee River; thence down the mid-channel of the Snake River to the mouth of the Clearwater; and thence north on the meridian which passes through the mouth of the Clearwater to the boundary line between the United States and the British Possessions; and east on said boundary line to the place of beginning.

On July 3, 1890, Idaho was admitted as a State, with the above limits.

The west boundary of Idaho, from the mouth of Clearwater River to the forty-ninth parallel, was surveyed and marked in 1873–74. The longitude of this line has been determined by the United States Geological Survey to be 117° 02′ 34″. The west boundary, from the mouth of Owyhee River south to the Nevada boundary, was surveyed and marked in 1867. Its longitude has been determined as 117° 01′ 56″ by the United States Geological Survey. Both these lines were run under the General Land Office.

OREGON.

Oregon Territory was organized August 14, 1848. The grounds of our title to its area are obscure. In treating with Great Britain for the establishment of our northern boundary west of the Rocky Mountains this region was claimed on three grounds—that of discovery and occupation, the Louisiana purchase, and cession from Spain. On which of these grounds we succeeded in having the boundary established on the forty-ninth parallel will never be ascertained, and is of little moment.

The Territory as originally established extended from the forty-second to the forty-ninth parallel, and from the Pacific Ocean to the crest of the Rocky Mountains, with boundaries defined in the organizing act as follows:

> All that part of the territory of the United States which lies west of the summit of the Rocky Mountains, north of the forty-second degree of north latitude, known as the Territory of Oregon, shall be organized into and constitute a temporary government by the name of the Territory of Oregon. (Thirtieth Congress, first session.)

In 1853 the Territory was reduced by the formation of Washington Territory (*vide* Washington, p. 136), and on February 14, 1859, it was admitted as a State with its present boundaries. These are defined below in an extract from the State constitution:

> Beginning one marine league at sea due west from the point where the forty-second parallel of north latitude intersects the same; thence northerly, at the same distance from the line of the coast lying west and opposite the State, including all islands within the jurisdiction of the United States, to a point due west and opposite the middle of the north ship channel of the Columbia River; thence easterly to and up the middle channel of said river, and where it is divided by islands, up the middle of the widest channel thereof, and in like manner up the middle of the main channel of Snake River to the mouth of the Owyhee River; thence due south to the parallel

of latitude forty-two degrees north; thence west along said parallel to the place of beginning, including jurisdiction in civil and criminal cases upon the Columbia River and Snake River concurrently with States and Territories of which those rivers form a boundary in common with this State. But the Congress of the United States, in providing for the admission of this State into the Union, may make the said northern boundary conform to the act creating the Territory of Washington.

The boundary line between Oregon and Washington on the forty-sixth parallel of latitude was surveyed and marked in 1864, under the General Land Office.

WASHINGTON.

This was organized March 2, 1853, from a part of Oregon Territory. Its limits, as originally constituted, were as given in the following clause from the act of Congress creating it:

> That from and after the passage of this act all that portion of Oregon Territory lying and being south of the forty-ninth degree of north latitude, and north of the middle of the main channel of the Columbia River from its mouth to where the forty-sixth degree of north latitude crosses said river, near Fort Walla Walla, thence with said forty-sixth degree of latitude to the summit of the Rocky Mountains, be organized into and constitute a temporary government by the name of the Territory of Washington. (Thirty-second Congress, second session.)

In 1859, on the formation of the State of Oregon, the residue of the Territory of Oregon, being the portion lying east of the present limits of the State, extending thence to the crest of the Rocky Mountains, was added to Washington. This area, with the part of Washington lying east of its present limits, was included in Idaho on the formation of that Territory in 1863.

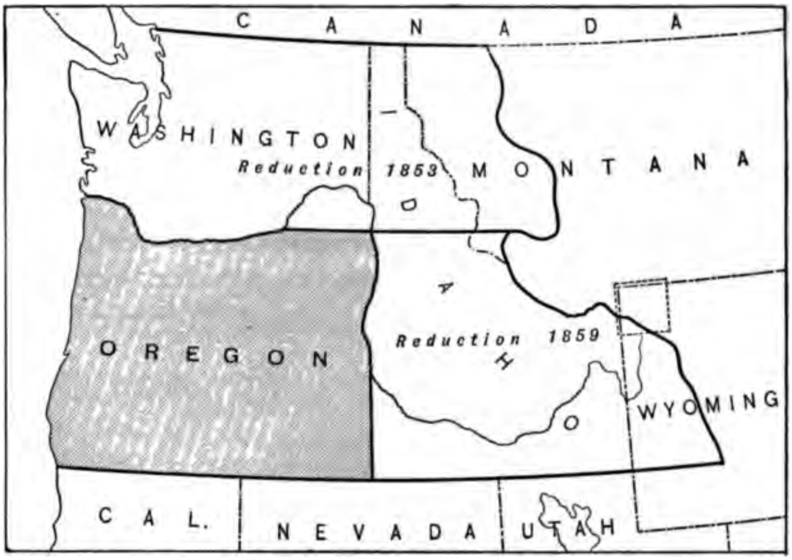
The present boundaries of Washington Territory are as follows: Beginning on the coast at the mouth of the Columbia River; following up the main channel of the Columbia River to its point of intersection with the forty-sixth parallel of latitude; thence east on the forty-sixth parallel to the Snake River; thence down the main channel of the Snake River to the mouth of the Clearwater; thence north on the meridian which passes through the mouth of the Clearwater to the boundary line between the United States and the British possessions; thence west with that boundary line to the Pacific.

Washington was admitted as a State on November 11, 1889, with its limits as above defined.

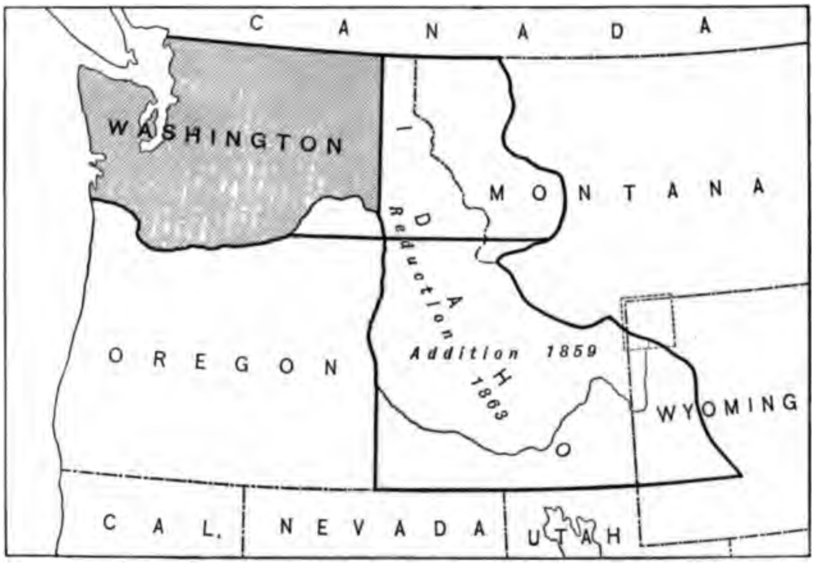
CALIFORNIA.

California was admitted to the Union on September 9, 1850. Its area was taken from territory acquired from Mexico by the treaty of Guadelupe-Hidalgo. Its limits, as defined in the State constitution, are as follows:

> Commencing at the point of intersection of forty-second degree of north latitude with the one hundred and twentieth degree of longitude west from Greenwich, and running south on the line of said one hundred and twentieth degree of west longitude until it intersects the thirty-ninth degree of north latitude; thence running in



HISTORICAL DIAGRAM OF OREGON.



HISTORICAL DIAGRAM OF WASHINGTON.

a straight line in a southeasterly direction to the river Colorado, at a point where it intersects the thirty-fifth degree of north latitude; thence down the middle of the channel of said river to the boundary line between the United States and Mexico as established by the treaty of May 30, 1848; thence running west and along said boundary line to the Pacific Ocean, and extending therein three English miles; thence running in a northwesterly direction and following the direction of the Pacific coast to the forty-second degree of north latitude; thence on the line of said forty-second degree of north latitude to the place of beginning. Also all the islands, harbors, and bays along and adjacent to the Pacific coast.

The northern boundary was surveyed and marked in 1868–69, under the General Land Office.

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56TH CONGRESS, } HOUSE OF REPRESENTATIVES. { DOCUMENT
1st Session. } { No. 746.

DEPARTMENT OF THE INTERIOR

BULLETIN

OF THE

UNITED STATES

GEOLOGICAL SURVEY

No. 172

BIBLIOGRAPHY AND INDEX OF NORTH AMERICAN
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MINERALOGY FOR 1899.—WEEKS

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

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OF

NORTH AMERICAN GEOLOGY, PALEONTOLOGY, PETROLOGY AND MINERALOGY

FOR

THE YEAR 1899

BY

FRED BOUGHTON WEEKS

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

CONTENTS.

LETTER OF TRANSMITTAL.

Department of the Interior,
United States Geological Survey,
Division of Geology,
Washington, D. C., June 12, 1900.

Sir: I have the honor to transmit herewith the manuscript of a Bibliography and Index of North American Geology, Paleontology, Petrology, and Mineralogy for the Year 1899, and to request that it be published as a bulletin of the Survey.

Very respectfully,

F. B. Weeks.

Hon. Charles D. Walcott,
Director United States Geological Survey.

BIBLIOGRAPHY AND INDEX OF NORTH AMERICAN GEOLOGY, PALEONTOLOGY, PETROLOGY, AND MINERALOGY FOR THE YEAR 1899.

By Fred Boughton Weeks.

INTRODUCTION.

The method of preparing and arranging the material of the Bibliography and Index for 1899 is similar to that adopted for the previous publications on this subject (Bulletins Nos. 130, 135, 146, 149, 156, and 162). Several papers that should have been entered in the previous bulletins are here recorded and the date of publication is given with each entry.

Bibliography.—The bibliography consists of full titles of separate papers, classified by authors, an abbreviated reference to the publication in which the paper is printed, and a brief summary of the contents, each paper being numbered for index reference. The extent of papers less than a single page in length is indicated as ⅛ p., 5 l (lines).

Index.—The subject headings, their subdivision and arrangement, are shown in the Classified Key to the Index. They comprise geographic, geologic, mineralogic, paleontologic, and petrologic subdivisions. Under Economic Geology is given a list of the useful minerals and ores described in publications examined; under Mineralogy, a list of minerals described in such publications; under Paleontology, a list of genera and species of fossils therein described, and under Petrology, a list of rocks described, reference being made in each case, by author's name and number of article in the Bibliography, to the pape. in which the fossil, mineral, or rock is described.

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105 —— and **Smyth** (H. L.). The Crystal Falls iron-bearing district of Michigan. With a chapter on the Sturgeon River tongue by W. S. Bayley, and an introduction by C. R. Van Hise.

U. S. Geol. Surv., Mon. XXXVI, 512 pp., 53 pls., 24 figs.; 19th Ann. Rept., Pt. III, pp. 19–151, pls. i–xi, figs. 1–6, 1899. Review: Am. Geol., vol. xxiv, pp. 308–311, 1899.

Describes the physiography of the region and the occurrence and character of the Archean and Algonkian formations and of the iron-ore deposits. Includes geologic maps.

106 **Coleman** (Arthur P.). Lake Iroquois and its predecessor at Toronto [Canada.]

Geol. Soc. Am. Bull., vol. x, pp. 165–176, 1899. Abstracts: Am. Geol., vol. xxxiii, pp. 103–104 (⅓ p.); Science, new ser., vol. ix, pp. 143–144, 1899.

Describes glacial features of the region.

107 —— A new analcite rock from Lake Superior.

Jour. of Geol., vol. vii, pp. 431–436, 1899.

Describes the occurrence and petrographic and chemical characters.

108 —— Corundiferous nepheline syenite from eastern Ontario.

Jour. Geol., vol. vii, pp. 437–444, 1899.

Describes occurrence and petrographic character.

109 —— Copper regions of the upper lakes [Ontario].

Ont. Bur. of Mines, vol. viii, pp. 121–174, 12 pls., 1899.

Describes the general physiographic and geologic features of the region and the character and occurrence of the Archean rocks and Algonkian and Pleistocene deposits. Includes notes on the petrographic characters of the igneous rocks.

110 —— Corundiferous nephelite syenite.

Ont. Bur. of Mines, vol. viii, pp. 250–253, 1899.

Describes character and occurrence in Ontario.

111 —— Copper in Parry Sound district [Ontario].

Ont. Bur. of Mines, vol. viii, pp. 259–262, 1899.

Describes character and occurrence of copper ores.

112 —— and **Willmott** (A. B.). Michipicoton iron range.

Ont. Bur. of Mines, vol. viii, pp. 254–258, 1899.

Describes occurrence of iron in the region.

113 **Colquhoun** (A. J.). Notes on occurrence of quicksilver in Canada.

Can. Min. Inst. Jour., vol. ii, pp. 13–16; Can. Min. Rev., vol. xviii, pp. 41–42; Min. and Sci. Press, vol. lxxix, p. 288, 1899.

114 **Comely** (V. R. de). The gold resources of Mexico.

Eng. and Min. Jour., vol. lxvii, pp. 320–321, 348, 1899.

Describes general occurrence of auriferous veins and placers.

115 **Cooper** (A. S.). The genesis of petroleum and asphaltum in California.

Cal. State Min. Bureau Bull., No. 16, 89 pp., 29 figs., 1899.

116 —— The genesis of petroleum and asphaltum in California.

Min. and Sci. Press, vol. lxxviii, pp. 124, 149, 182, 205 (2 figs.), 236 (1 fig.), 264 (2 figs.), 289–290 (1 fig.), 320 (1 fig.), 344 (2 figs.), 377 (1 fig.), 401–402, 432 (1 fig.), 460 (1 fig.), 1899.

Describes occurrence and discusses origin.

117 **Cooper** (A. S.). Phenomena accompanying the accumulations of bitumen.

Min. and Sci. Press. vol. lxxix, pp. 632–633 (3 figs.), 655 (3 figs.), 691 (1 fig.), 721, 1899.

Describes occurrences.

118 **Cope** (Edward D.). Vertebrate remains from Port Kennedy bone deposit [Pennsylvania].

Phil. Acad. Nat. Sci. Jour., 2nd ser., vol. xi, pt. ii, pp. 193–267, pls. xix–xxi, 1899.

119 **Crook** (A. R.). Oliver Marcy, LL. D.

Am. Geol., vol. xxiv, pp. 67–72, pl. iv, 1899.

Gives a sketch of Professor Marcy's life.

120 **Crosby** (W. O.). Archean-Cambrian contact near Manitou, Colorado.

Geol. Soc. Am., Bull., vol. x, pp. 141–164, pls. xiv–xviii, 38 figs. 1899. Abstracts: Am. Geol., vol. xxiii, p. 92; Science, new ser., vol. ix, p. 101 (½ p.), 1899.

Describes the contact, the structural features, modes of erosion, and the relation of the form of the contacts and the character of the overlying sediments.

121 —— Geology of the Wachusett dam and Wachusett aqueduct tunnel of the Metropolitan waterworks in the vicinity of Clinton, Massachusetts.

Tech. Quart., vol. xii, pp. 68–96, 10 figs., 1899.

Describes the character and occurrence of the sedimentary and igneous rocks and structure features of the region.

122 —— Geological history of the Nashua Valley during the Tertiary and Quaternary periods.

Tech. Quart., vol. xii, pp. 288–324, 4 pls., 1899.

Describes the physiography and character of the Tertiary and Pleistocene drainage.

123 —— [Review of "The genesis of bitumens as related to chemical geology," by S. F. Peckham.]

Am. Geol., vol. xxiii, p. 327 (4 l.), 1899.

124 —— [Review of "Notes on North Carolina minerals," by J. H. Pratt.]

Am. Geol., vol. xxiii, pp. 325–326, (½ p.), 1899.

125 —— [Review of "The origin and chemical composition of petroleum," by S. P. Sadtler, S. F. Peckham, David T. Day, Francis C. Phillips, and Charles F. Mabery.]

Am. Geol., vol. xxiii, pp. 326–327, 1899.

126 **Crosby** (W. O.). [Review of "Origin of grahamite," by I. C. White; "A contribution to the study of contact metamorphism," by J. Morgan Clements; "The petrographical province of Essex County, Mass.," by H. S. Washington; and "A contribution to the geology of the pre-Cambrian igneous rocks of the Fox River Valley, Wisconsin," by Samuel Weidman.]

Am. Geol., vol. xxiv, pp. 253–257, 1899.

127 —— The glacial lake of Nashua Valley.

Abstracts: Am. Geol., vol. xxiii, pp. 102–103 (½ p.); Science, new ser., vol. ix, p. 106 (⅛ p.), 1899.

128 **Cross** (Whitman). Telluride folio, Colorado.

U. S. Geol. Survey, Geol. Atlas of U. S., folio No. 57, 1899.

Describes the general physiography and geology of the San Juan region, and the occurrence and character of the Algonkian, Juratrias, Cretaceous, Tertiary, and igneous rocks of the quadrangle and discusses the geologic history. Includes topographic and geologic maps, columnar sections, and special illustrations.

129 —— See **Hill** (R. T.). No. 313.

130 **Cummings** (Uriah). American cements.

Rogers and Manson, Boston, 299 pp., 1898. Review: Jour. of Geol., vol. vii, p. 627 (½ p.), 1899.

131 **Curtis** (G. C.) and **Woodworth** (J. B.). Nantucket, a morainal island.

Jour. of Geol., vol. vii, pp. 226–236, 5 figs., 1899.

Describes the physiographic, glacial, and general geologic features of the region.

132 **Cushing** (H. P.). Augite-syenite gneiss near Loon Lake, New York.

Geol. Soc. Am., Bull., vol. x, pp. 177–192, pls. 19–20, 1899. Abstracts: Am. Geol., vol. xxiii, pp. 106, 330–331; Science, new ser., vol. ix, p. 141, 1899.

Describes megascopic, microscopic, and chemical character of the gneiss and its occurrence in the petrographic provinces. Discusses sequence of eruptions in the Adirondacks.

133 —— Report on the boundary between the Potsdam and pre-Cambrian rocks of the Adirondacks [New York].

N. Y. Geol. Surv., 16th Ann. Rept., pp. 5–27, 1 pl., 2 figs. 1899. Review: Am. Geol., vol. xxiii, p. 330, 1899.

Describes the geologic history and local geologic features of the region.

D.

134 **Dale** (T. Nelson). The slate belt of eastern New York and western Vermont.

U. S. Geol. Surv., 19th Ann. Rept., Pt. III, pp. 153–300, pls. xii–xli, figs. 7–16, 1899.

Describes the physiography, the occurrence, and character and structure of the Cambrian and Ordovician beds, the chemical composition of the slates, and the economic geology of the region. Includes a bibliography of the subject.

135 **Dall** (Wm. H.) Synopsis of the Recent and Tertiary Leptonacea of North America and the West Indies.
U. S. Nat. Mus., Proc., vol. xxi, pp. 873–897, pls. lxxxvii–lxxxviii, 1899.

136 **Daly** (R. A.). On the optical characters of the vertical zone of amphiboles and pyroxenes; and on a new method of determining the extinction angles of these minerals by means of cleavage planes.
Am. Acad. Arts and Sci., Proc., vol. xxxiv, pp. 309–323, pls. i–iii, 1899.

137 —— On a new variety of hornblende.
Am. Acad. Arts and Sci., Proc., vol. xxxiv, pp. 431–437, 1899.

138 —— The peneplain. A review.
Am. Nat., vol. xxxiii, pp. 127–138, 1899.
Discusses Professor Tarr's criticisms of the peneplain theory.

139 **Darton** (Nelson Horatio). Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian.
U. S. Geol. Surv., 19th Ann. Rept., Pt. IV, pp. 719–785, pls. lxxiv–cxviii, figs. 208–230, 1899.
Describes the physiography, the character and occurrence of the Pleistocene, Tertiary, and Cretaceous strata and of the underground waters.

140 —— The bad lands of South Dakota.
Nat. Geog. Mag., vol. x, pp. 339–343, 3 pls., 1899.
Describes the general geologic and physiographic features of the region.

141 —— Fossil fish in Jurassic of Black Hills.
Abstracts: Am. Geol., vol. xxiii, p. 93 (4 l.), 1899; Science, new ser., vol. ix, p. 103 (7 l.), 1899.

141*a* —— Mesozoic stratigraphy in southwestern Black Hills.
Abstracts: Am. Geol., vol. xxiii, p. 94 (¼ p.), 1899; Science, new ser., vol. ix, p. 103 (¼ p.), 1899.

141*b* —— Relations of Tertiary formations in western Nebraska region.
Abstracts: Am. Geol., vol. xxiii, p. 94 (½ p.), 1899; Science, new ser., vol. ix, p. 103 (5 l.), 1899.

141*c* —— Shore line of Tertiary lakes on slope of the Black Hills.
Abstracts: Am. Geol., vol. xxiii, p. 94 (9 l.), 1899; Science, new ser., vol. ix, p. 103 (8 l.), 1899.

142 —— **Clarke** (F. W.) and. Hydromica from New Jersey.
See Clarke (F. W.) and Darton (N. H.), No. 95.

143 **Davis** (H. J.). Modification in the Jonathan Creek drainage basin [Ohio.]
Denison Univ., Sci. Lab. Bull., vol. xi, art. viii, pp. 163–165, pls. xxv–xxvi, 1899.
Describes the physiographic features of the region.

144 **Davis** (W. M.). The peneplain.
Am. Geol., vol. xxiii, pp. 207–239, pl. vii, 1899.
Discusses evidences bearing on the existence of peneplains.

145 **Davison** (J. M.). Platinum and iridium in meteoric iron.
Am. Jour. Sci., 4th ser., vol. vii, p. 4, 1899. Review: Am. Geol., vol. xxiii, p. 327 (9 l.), 1899.

146 **Dawson** (George M.). Summary report of the Geological Survey department [Canada] for the year 1897.
Can. Geol Surv., new ser., vol. x, Rept. A, 156 pp. and map, 1898.
Contains a general summary of the operations of the survey and of the annual reports of the several geologists.

147 —— Summary report of the Geological Survey department of [Canada] for the year 1898.
Can. Geol. Surv., 208 pp., 1899. Review: Am. Geol., vol. xxiii, pp. 384–385, 1899.

148 —— The coals of the Canadian northwest and Rocky Mountain region.
The Mineral Industry for 1898, vol. vii, pp. 198–201, 1899.
Describes occurrence and distribution.

149 —— A remarkable landslip on the Riviere Blanche, Port Neuf Co., Quebec.
Abstracts: Am. Geol., vol. 23, p. 103 (⅛ p.); Science, new ser., vol. ix, p. 139 (9 l.), 1899.

150 —— Duplication of geologic formation names.
Science, new ser., vol. ix, pp. 592–593, 1899.
Discusses use of the name Cache Creek formation.

151 **Dawson** (Sir J. William). Note on an echinoderm collected by Dr. Ami at Bessrers, Ottawa River, in the Pleistocene (Leda clay).
Ottawa Nat., vol. xiii, pp. 201–202, 1899.
Contains notes on a specimen representing a species of Spatangus or Brissus.

152 —— Addendum to a note of Nova Scotia Carboniferous Entomostraca in number for January, 1897.
Can. Rec. Sci., vol. vii, p. 396, fig. 10, 1898.
Gives figure of Carbonia rankiniana.

153 **Day** (David T.). Mineral Resources of the Antilles, Hawaii, and the Philippines.
Eng. Mag., vol. xvii, pp. 242–251, 1899.
Gives a general account of the mineral resources of these islands.

154 **Day** (William C.). The coal and pitch coal of the Newport mine [Oregon].
U. S. Geol. Surv., 19th Ann. Rept., Pt. III, pp. 370–376, 1899.
Discusses the character and origin of certain portions of these coal beds.

155 **Day** (William C.). See **Taff** (J. A.). No. 617.

156 **Dickhaut** (Henry E.). Collecting fossils in the Cincinnati shales.
Am. Geol., vol. xxiii, pp. 335–336, 1899.
Contains notes on the occurrence of fossils in these shales and recommendations as to the best part of the year to collect fossils from this region.

157 **Diller** (Joseph Silas). The Coos Bay coal field, Oregon.
U. S. Geol. Surv., 19th Ann. Rept., Pt. III, pp. 309–376, pls. xliii–liv, figs. 17–76, 1899.
Describes the topographic and geologic features of the region and the occurrences and character of the coals.

158 —— Origin of Paleotrochis.
Am. Jour. Sci., 4th ser., vol. vii, pp. 337–342, 1899. Review: Am. Geol., vol. xxiv, p. 182 (½ p.), 1899.
Describes microscopic characters of the material and origin of the Paleotrochis structure.

159 —— Crater Lake, Oregon.
Smith. Inst., Ann. Rept. for 1897, pp. 369–379, pls. ii–xvi, 1898.

160 —— Latest volcanic eruption on the Pacific coast.
Science, new ser., vol. ix, pp. 639–640, 1899.
Describes material from Mount St. Helens, Washington.

161 —— The educational series of rock specimens collected and distributed by the United States Geological Survey.
Abstract: Am. Geol., vol. xxiii, pp. 61–62, 1899.

162 **Domenech** (Manuel Victor). [Mineral resources of Porto Rico.]
Mines and Minerals, vol. xix, pp. 529–532, 1 fig., 1899.
Describes occurrence of gold, silver, copper, and iron.

163 **Donald** (J. T.). A notable Canadian deposit of chromite.
Can. Min. Inst., Jour., vol. ii, pp. 25–27, 1899; Can. Min. Rev., vol. xviii, pp. 40–41, 1899.
Contains notes on occurrence.

164 **Douglas** (James). The Copper Queen mine, Arizona.
Min. and Sci. Press, vol. lxxix, pp. 432–433, 2 figs., 1899.

165 **Douvillé** (M. H.). Sur l'âge des couches traversées par le canal de Panama.
Soc. Géol de France, Bull., 3d ser., vol. xxvi, pp. 587–600, 1898.

E.

166 **Eakle** (Arthur S.). Topaz crystals in the mineral collection of the U. S. National Museum.
U. S. Nat. Mus. Proc., vol. xxi, pp. 361–369, 22 figs., 1899; published in 1898.
Describes crystallographic characters.

167 **Eastman** (C. R.). Descriptions of new species of Diplodus teeth from the Devonian of northeastern Illinois.

Jour. of Geol., vol. vii, pp. 489–493, pl. vii, 1899.

Describes two new species of Diplodus.

168 **Eckel** (E. C.). Intrusiyes in the Inwood limestone of Manhattan Island.

Am. Geol., vol. xxiii, pp. 122–124, pl. iii, 1899.

Describes the relations of the formations and the character and occurrence of the intrusives.

169 **Ehrenfeld** (Frederick). A study of the igneous rocks at York Haven and Stony Brook, Pa., and their accompanying formations.

Thesis presented to the faculty of the department of philosophy of the University of Pennsylvania, 24 pp., 1 pl., 1898. (Not seen.)

170 **Eldridge** (George H.). The extreme southeastern coast. The coast from Lynn Canal to Prince William Sound [Alaska].

U. S. Geol. Surv., Expl. in Alaska, pp. 101–104, 1899.

Describes occurrence of gold and coal in the region.

171 —— The Sushitna drainage area [Alaska].

U. S. Geol. Surv., Expl. in Alaska, pp. 111–112, 1899.

Describes general physiographic and geologic features.

172 —— and **Muldrow** (Robert). Report of the Sushitna expedition [Alaska].

U. S. Geol. Surv., Expl. in Alaska, pp. 15–27, 1899.

Describes the physiography, the character and occurrence of the granite and sedimentary formations, and the geologic structure and mineral resources of the region.

173 **Elftman** (Arthur H.). Preliminary report of field work during the summer 1895.

Minn. Geol. and Nat. Hist. Surv., 24th Ann. Rept., pp. 148–149, 1899.

Brief notes on the occurrence of anorthosytes.

174 —— List of rock samples collected in northeastern Minnesota in 1895, 1896, and 1897 (prepared by U. S. Grant).

Minn. Geol. and Nat. Hist. Surv., 24th Ann. Rept., pp. 150–170, 1899.

175 **Ells** (R. W.). Problems in Quebec geology.

Can. Rec. Sci., vol. vii, pp. 480–502, 1898.

Gives a general review of the publications on Quebec geology and discusses the problems involved.

176 **Emerson** (B. K.). The geology of eastern Berkshire County, Massachusetts.

U. S. Geol. Surv., Bull. No. 159, 139 pp., 9 pls., 16 figs., 1899.

Describes the occurrence, character, and structure of the pre-Cambrian, Cambrian, Silurian, Glacial, and post-Glacial deposits, and gives an account of the mineral resources and a mineral lexicon and bibliography of the region.

177 **Emerson** (B. K.). Differences of batholitic granites, according to depth of erosion.

Abstracts: Am. Geol., vol. xxiii, pp. 104–105; Science, new ser., vol. ix, p. 140 (⅓ p.), 1899.

178 **Emmons** (S. F.). Plutonic plugs and subtuberant mountains.

Abstract: Science, new ser., vol. x, pp. 24–25, 1899.

F.

179 **Fairbanks** (Harold W.). Some notes on the petroleum deposits of California.

Min. and Sci. Press, vol. lxxviii, p. 533, 1899.

Discusses occurrence and origin.

180 **Fairchild** (Herman Le Roy). Glacial waters in the Finger Lakes region of New York.

Geol. Soc. Am., Bull., vol. x, pp. 27–68, pls. iii–ix, 1899.

Describes the glacial lakes that occupied the various valleys of the region.

181 —— Glacial Lakes Newberry, Warren, and Dana, in central New York.

Am. Jour. Sci., 4th ser., vol. vii, pp. 249–263, 1 fig., pl. vi, 1899.

Describes general character, extent, and shore lines and elevations of the glacial lakes.

182 **Faribault** (E. R.). On the gold measures of Nova Scotia, and deep mining.

Can. Min. Inst., Jour., vol. ii, pp. 119–129; Can. Min. Rev., vol. xviii, p. 78, 1899.

Describes geologic structure and occurrence of gold in the region.

183 **Farrington** (Oliver C.). A fossil egg from South Dakota.

Field Col. Mus., Geol. ser., vol. i, No. 5, pp. 192–200, pls. xx–xxi, figs. 1–2, 1899.

184 **Finch** (J. W.). [Review of "Iowa Geological Survey, Ann. Rept. 1898, vol. ix."]

Jour. of Geol., vol. vii, pp. 517–521, 1899.

185 **Fleming** (Mary A.). The potholes of Fosters Flats (now called Niagara Glen) on the Niagara River.

Abstracts: Am. Assoc. Adv. Sci., Proc., vol. xlviii, pp. 226–227 (⅓ p.); Science, new ser., vol. x, p. 489 (⅓ p.), 1899.

186 **Foerste** (August F.). Age and development of the Cincinnati anticline.

Abstract: Science, new ser., vol. x, p. 488 (½ p.), 1899.

187 —— **Shaler** (N. S.), **Woodworth** (J. B.), and. Geology of the Narragansett Basin.

See Shaler (N. S.), Woodworth (J. B.), and Foerste (A. F.), No. 582.

188 **Fontaine** (W. M.). Notes on Lower Cretaceous plants from the Hay Creek coal field, Crook County, Wyoming.

. U. S. Geol. Surv., 19th Ann. Rept., Pt. II, pp. 645–702, pls. clx–clxix, 1899.

Describes the section of the coal beds and the fossils collected.

189 —— See **Ward** (L. F.), No. 690.

190 **Foote** (H. W.), **Penfield** (S. L.) and. Chemical composition of tourmaline.

See Penfield (S. L.) and Foote (H. W), No. 520.

191 **Foote** (Warren M.). Note on a new meteoric iron found near the Tombigbee River, in Choctaw and Sumter counties, Alabama.

Am. Jour. Sci., 4th ser., vol. viii, pp. 153–156, pls. ii–iii, 1899. Review: Am. Geol., vol. xxiv, p. 319 (8 l.), 1899.

Describes the occurrence and physical and chemical characters of the material.

192 —— Note on a new meteoric iron found near Iredell, Bosque County, Texas, U. S. A.

Am. Jour. Sci., 4th ser., vol. viii, pp. 415–416, 1899.

Describes occurrence and chemical character of the material.

193 **Forsyth** (A.), **O'Harra** (C. C.) and. Notes on the geology and mineral deposits of a portion of the southern Black Hills.

See O'Harra (C. C.) and Forsyth (A.), No. 502.

194 **Fowler** (S. S.). Notes on the Ymir mine and its mill practice [British Columbia].

Min. and Sci. Press, vol. lxxix, p. 517, 1899.

Describes geologic features and occurrence of gold and silver ores.

195 **Fuller** (Myron L.). Season and time elements in sand-plain formation.

Jour. of Geol., vol. vii, pp. 452–462, 1 fig., 1899.

Discusses origin of certain glacial deposits.

196 —— Notes on an unusual orientation of phenocrysts in a dike.

Tech. Quart., vol. xii, pp. 175–179, 2 figs., 1899.

Describes phenocrysts of a porphyritic granite.

197 —— The occurrence and uses of mica.

Stone, vol. xix, pp. 530–532, 1899.

198 —— [Review of "Mineralogical notes, analyses of tysonite, bastnasite, prosopite, jeffersonite, covellite," etc., by W. F. Hillebrand.]

Am. Geol., vol. xxiii, pp. 324–325 (½ p.), 1899.

199 **Fuller** (Myron L.). [Review of "On the chemical composition of tourmaline," by S. L. Penfield and H. W. Foote.]
Am. Geol., vol. xxiii, p. 325 (½ p.), 1899.

200 —— [Review of "On dikes of felsophyre and basalt in Paleozoic rocks in central Appalachian Virginia," by N. H. Darton, and "Notes on the petrography," by Arthur Keith.]
Am. Geol., vol. xxiii, p. 327 (6 l.), 1899.

201 —— [Review of "Platinum and iridium in meteoric iron," by J. M. Davison.]
Am. Geol., vol. xxiii, p. 327, (9 l.), 1899.

202 —— [Review of "Causes of variation in composition of igneous rocks," by T. L. Walker.]
Am. Geol., vol. xxiii, pp. 327–328, (½ p.), 1899.

203 —— [Review of "On the associated minerals of rhodolite," by W. E. Hidden and J. H. Pratt.]
Am. Geol., vol. xxiii, p. 328 (5 l.), 1899.

204 —— [Review of "The alkaline reaction of some natural silicates," by F. W. Clarke.]
Am. Geol., vol. xxiii, p. 328 (7 l.), 1899.

205 —— [Review of "Petroleum inclusions in quartz crystals," by Chas. L. Reese.]
Am. Geol., vol. xxiii, p. 328 (3 l.), 1899.

206 —— [Review of "Mineral resources of Cuba," by Raimundo Cabrera.]
Am. Geol., vol. xxiii, p. 328 (3 l.), 1899.
See Bibliography and Index for 1899, No. 117.

207 —— [Review of "The slate region of Pennsylvania," by Mansfield Merriam.]
Am. Geol., vol. xxiii, p. 328 (5 l.), 1899.

208 —— [Review of "On the phenocrysts of intrusive igneous rocks," by L. V. Pirsson; "On the occurrence, origin, and chemical composition of chromite," by J. H. Pratt; "Some rock-forming biotites and amphiboles," by H. W. Turner; "On the occurrence of Paleotrochis in volcanic rocks in Mexico," by H. S. Williams; "Origin of Paleotrochis," by J. S. Diller; "Goldschmidtite, a new mineral," by W. H. Hobbs; and "On a hydromica from New Jersey," by F. W. Clarke and N. H. Darton.]
Am. Geol., vol. xxiv, pp. 180–182, 1899.

209 **Fuller** (Myron L.). [Review of "Analysis and composition of roscoelite," by W. F. Hillebrand; "Chemical composition of roscoelite," by F. W. Clarke; "The occurrence of roscoelite," by H. W. Turner; "On the chemical composition of parisite and a new occurrence of it in Ravalli County, Mont.," by S. L. Penfield and C. H. Warren; "The constitution of tourmaline," by F. W. Clarke; "Note on a new meteoric iron found near Tombigbee River in Choctaw and Sumter counties, Alabama, U. S. A.," by Warren M. Foote; "An Albertite-like asphalt in the Choctaw Nation, Indian Territory," by J. A. Taff; "On the separation of alumina from molten magmas and the formation of corundum," by J. H. Pratt; "Experiments relative to the constitution of pectolite, pyrophillite, calamine, and analcite," by F. W. Clarke and George Steiger; "The mineralogical structure and chemical composition of the trap of Rocky Hill, N. J.," by A. H. Phillips; "Mineralogical notes; melonite, coloradoite, petzite, hessite," by W. F. Hillebrand.]
Am. Geol., vol. xxiv, pp. 317-321, 1899.

210 **Fulton** (R. L.). Nevada sulphur deposits.
Eng. and Min. Jour., vol. lxviii, p. 64 (½ p.), 1899.
Briefly describes occurrence and character.

211 **Fultz** (Francis M.). The Burlington artesian well [Iowa].
Iowa Acad. Sci., Proc., vol. vi, pp. 70-74, 1899.
Gives section of well to a depth of 2,430 feet.

G.

212 **Gallaher** (John A.). Bureau of geology and mines.
Missouri, Biennial Rept. 1898, 68 pp.
Describes general geologic features of the State.

213 **Gannett** (Henry). A dictionary of altitudes in the United States. (Third edition).
U. S. Geol. Surv., Bull., No. 160, 775 pp. 1899.

214 **Gassaway** (A. D.). The Magalia, Cal., drift mine.
Min. and Sci. Press, vol. lxxviii, pp. 372-373 (3 figs.), 400-401 (3 figs.), 1899.

215 **Geraland** (George). Modern studies of earthquakes.
Pop. Sci. Mo., vol. liv, pp. 362-371, 1899.

216 **Gibson** (T. W.). The corundum deposits of Ontario.
Eng. and Min. Jour., vol. lxvii, p. 500, 1899.
Describes general character and occurrence.

217 **Gilbert** (Grove Karl). Glacial sculpture in western New York.

Geol. Soc. Am., Bull., vol. x, pp. 121–130, 1899. Abstracts: Am. Geol., vol. xxiii, p. 103 (8 l.); Science, new ser., vol. ix, p. 143 (½ p.), 1899.

Describes sculpture of the Niagara, Clinton, and Medina strata.

218 —— Dislocation at Thirtymile point, New York.

Geol. Soc. Am., Bull., vol. x, pp. 131–134, pl. xii, 2 figs., 1899.

Describes overturned fold in Medina formation and discusses origin of the structure.

219 —— Ripple marks and cross bedding.

Geol. Soc. Am., Bull., vol. x, pp. 135–140, pl. xiii, 5 figs., 1899. Abstracts: Am. Geol., vol. xxiii, p. 102 (½ p.); Science, new ser., vol. ix, p. 138 (½ p.), 1899.

Describes occurrence in the Medina formation.

220 —— [Review of "The great ice dams of Lakes Maumee, Whittlesly, and Warren," by F. B. Taylor.]

Jour. of Geol., vol. vii, pp. 621–623, 1899.

221 —— Recent earth movement in the Great Lakes region.

Abstracts: Am. Geol., vol. xxiii, pp. 126–127; Am. Jour. Sci., 4th ser., vol. vii, pp. 239–241, 1899.

See Bibliography and Index for 1898, No. 289.

222 **Girty** (George H.). Preliminary report on Paleozoic invertebrate fossils from the region of the McAlester coal field, Indian Territory.

U. S. Geol. Surv., 19th Ann. Rept., Pt. III, pp. 539–593, pls. lxix–lxxii, 1899.

Describes the occurrence of the fossils and the relations of the beds in which they occur, and the general characteristics of the Lower Helderberg, Niagara, and Ordovician faunas. Discusses their relations to other faunas and describes the characters of the species collected.

223 —— Devonian and Carboniferous fossils. [Yellowstone National Park.]

U. S. Geol. Surv., Mon. XXXII, Pt. II, pp. 479–599, pls. lxvi–lxxi, 1899.

Discusses the relations of the faunas and describes the fossils collected.

224 **Glenn** (L. C.). The Hatteras axis in Triassic and Miocene time.

Am. Geol., vol. xxiii, pp. 375–379, 1899.

Describes the difference in Triassic sedimentation in North Carolina and in the Middle and North Atlantic States, and the occurrence of a land area in the Carolina region in early Miocene time.

225 **Goode** (John Paul). The piracy of the Yellowstone.

Jour. of Geol., vol. vii, pp. 261–271, 5 figs., 1899.

Describes the post-glacial history and drainage of the Upper Yellowstone Valley.

226 —— [Review of "Physical geography of New Jersey," by R. D. Salisbury.]

Jour. of Geol., vol. vii, pp. 314–316, 1899.

227 **Gorby** (S. S.). The onyx deposits of Barren County, Kentucky.

Eng. and Min. Jour., vol. lxvii, pp. 707–708, 2 figs., 1899.

Describes character and occurrence of the deposits.

228 **Gould** (C. N.). On the finding of fossil insects in the Comanche Cretaceous of Kansas.

Kan. Acad. Sci. Trans., vol. xvi, p. 284, 1899.

229 **Grabau** (Amadeus W.). The paleontology of the Eighteen Mile Creek and the Lake Shore sections of Erie County, New York.

Buffalo Soc. of Nat. Sci., Bull., vol. vi, pp. 93–403, 263 figs., 1899.

Discusses the elements of paleontology and describes the genera and species of fossils collected from the Devonian strata of the region. Includes bibliography and a discussion of the relation of marine bionomy to stratigraphy.

230 —— The faunas of the Hamilton group of Eighteen-mile Creek and vicinity, in western New York.

N. Y. Geol. Surv., 16th Ann. Rept., pp. 227–340, 5 pls., 6 figs., 1899.

Describes the stratigraphic features and the vertical distribution of the fossils of the Hamilton group of the region.

231 —— Moniloporidæ, a new family of Paleozoic corals.

Bost. Soc. Nat. Hist., Proc., vol. xxviii, pp. 409–424, 4 pls., 1899.

232 —— Some modern stratigraphic problems.

Abstract: Science, vol. x, p. 85 (½ p.), 1899.

233 **Grant** (C. C.). Geological notes.

Hamilton Assoc., Proc. and Trans., No. xv, pp. 48–64, 1899.

Contains notes on the Silurian strata and fossils in the vicinity of Hamilton, Ontario.

234 **Grant** (U. S.). The geology of Cook County [Minnesota].

Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 313–345, pl. lxix, HH-KK, 1899.

Describes the physiography and occurrence of the Archean and Cambrian rocks and glacial history and deposits of the region.

235 —— The geology of the Pokegama Lake plate [Minnesota].

Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 346–349, pl. lxx, 1899.

Describes character and occurrence of the Cambrian strata of the region.

236 —— The geology of the Grand Rapids plate [Minnesota].

Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 350–354, pl. lxxi, 1899.

Describes the character and occurrence of the granites and the Cambrian sediments of the region.

237 **Grant** (U. S.). The geology of the Swan Lake plate [Minnesota].
Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 355–357, pl. lxxii, 1899.
Describes briefly the occurrence of granitic rocks and Cambrian deposits.

238 —— The geology of the Gabbro Lake plate [Minnesota].
Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 399–419, pl. lxxxviii, and MM and PP, 1899.
Describes the character and occurrence of the Archean and Cambrian rocks.

239 —— The geology of the Snowbank Lake plate [Minnesota].
Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 420–433, pl. lxxix, 1899.
Describes drift deposits and Archean rocks of the region.

240 —— The geology of the Fraser Lake plate [Minnesota].
Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 434–461, pls. lxxx and LL, figs. 78–79, 1899.
Describes the topography and the occurrence and character of the Archean and Cambrian rocks.

241 —— The geology of the Akeley Lake plate [Minnesota].
Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 462–480, pl. lxxxi, figs. 80–87, 1899.
Describes the physiography, the character and occurrence of the Cambrian and Archean rocks and occurrence of iron ores.

242 —— The geology of the Gunflint Lake plate [Minnesota].
Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 481–490, pl. lxxxii, NN, figs. 88, 89, 1899.
Describes character and occurrence of the Cambrian rocks.

243 —— The geology of the Rove Lake plate [Minnesota].
Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 491–495, pl. lxxxiii, 1899.
Describes character and occurrence of the Cambrian rocks.

244 —— The geology of the Mountain Lake plate [Minnesota].
Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 496–501, pl. lxxxiv, fig. 90, 1899.
Describes character and occurrence of the Cambrian rocks and occurrence of silver.

245 —— Record of geological field work in northern Minnesota, 1892 to 1898.
Minn. Geol. and Nat. Hist. Surv., 24th Ann. Rept., pp. 85–144, 1899.

246 —— List of rock samples collected in northeastern Minnesota in 1898.
Minn. Geol. and Nat. Hist. Surv., 24th Ann. Rept., pp. 145–147, 1899.

247 **Grant** (U. S.). The geology of Itasca County [Minnesota].
Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 166–192, pl. lxv, 1899.
Describes the physiographic features and the character and occurrence of Archean rocks and Cretaceous and glacial deposits.

248 —— [Review of "The educational series of rock specimens collected and distributed by the United States Geological Survey," by J. S. Diller.]
Am. Geol., vol. xxiii, pp. 61–62, 1899.

249 —— [Review of "Recent earth movement in the Great Lakes region," by G. K. Gilbert.]
Am. Geol., vol. xxiii, pp. 126–127, 1899.

250 —— [Review of "Geology of Lake Placid region," by J. F. Kemp.]
Am. Geol., vol. xxiii, p. 195 (½ p.), 1899.

251 —— [Review of "The hardystonite, a new calcium zinc silicate from Franklin Furnace, New Jersey," by J. E. Wolff.]
Am. Geol., vol. xxiii, p. 329 (½ p.), 1899.

252 —— [Review of "Mineral resources of Kansas, 1898," by Erasmus Haworth; and "The Crystal Falls iron-bearing district of Michigan," by J. M. Clements and H. L. Smyth; with a chapter on the Sturgeon River tongue, by W. S. Bayley, and an introduction by C. R. Van Hise.]
Am. Geol., vol. xxiv, pp. 305 and 308–311, 1899.

253 —— A possible driftless area in northeastern Minnesota.
Am. Geol., vol. xxiv, pp. 377–381, 1899.
Describes the geologic features of the region and discusses the evidence bearing on the occurrence of a nonglaciated area.

254 —— See **Elftman** (A. H.), No. 174.

255 —— **Winchell** (H. V.) and. Preliminary report on the Rainy Lake gold region [Minnesota].
(See Winchell (H. V.) and Grant (U. S.), No. 780.)

256 **Gratacap** (L. P.). Notes on the limonite beds on Ocean terrace [Staten Island, New York].
Staten Island Nat. Sci. Assoc., Proc., vol. vii, No. 12, 2 pp., 1899.
Notes on occurrence of limonite.

257 —— The Comstock lode [Nevada].
Sci. Am. Suppl., vol. xlviii, pp. 19925–19926, 1 fig., 1899.

258 —— A plea for the popular exposition of lithology for museum purposes.
Am. Geol., vol. xxiii, pp. 281–287, 1899.

259 **Greene** (G. K.). Contributions to Indiana Paleontology, Pts. II and III.

Ewing and Zeller, New Albany, Ind., pp. 8-25, pls. 4-9, 1899. (Not seen.)

260 **Gregory** (H. E.). Andesite of the Aroostook volcanic area of Maine.

Am. Jour. Sci., 4th ser., vol. viii, pp. 359-369, 1899.

261 **Gresley** (W. S.). Side light upon coal formation.

Am. Geol., vol. xxiii, pp. 69-80, pl. ii, 1899.

Describes certain features of coal veins and associated strata and discusses their bearing on the origin of coal.

262 —— Possible new coal plants in coal.

Am. Geol., vol. xxiv, pp. 199-204, pls. vii-x, 1899.

Describes structure resembling plants.

263 **Grinnell** (George Bird). The glaciers in Montana.

Sci. Am. Suppl., vol. xlviii, p. 19854, 1899.

Describes existing glaciers.

264 **Gulliver** (F. P.). Shoreline topography.

Am. Acad. Arts and Sci., Proc., vol. xxxiv, pp. 149-258, figs. 1-32, 1899. Review: Jour. of Geol., vol. vii, pp. 827-829, 1899.

Describes the successive stage of development of shore lines as influenced by uplift and depression.

265 —— Classification of coastal forms.

Abstract: Geol. Soc. Am., Bull., vol. x, p. 18, 1899.

See Bibliography and Index for 1898, No. 322.

266 —— Note on monadnocks.

Abstract: Geol. Soc. Am., Bull., vol. x, p. 19 (8 l.), 1899.

267 —— Thames River in Connecticut.

Abstracts: Am. Geol., vol. xxiii, p. 104 (½ p.); Science, new ser., vol. ix, p. 144, 1899.

H.

268 **Hague** (Arnold). Absaroka folio, Wyoming.

U. S. Geol. Surv., Geologic Atlas of U. S., folio No. 52, 1899.

Describes the topographic features, the character and occurrence of the Archean, Cambrian, Silurian, Devonian, Carboniferous, Cretaceous, and volcanic rocks of the Crandall and Ishawooa quadrangles. Includes topographic and geologic maps and columnar sections.

269 —— Descriptive geology of Huckleberry Mountain and Big Game Ridge [Yellowstone National Park].

U. S. Geol. Surv., Mon. XXXII, Pt. II, pp. 165-202, pls. xxiv-xxv, 1899.

Describes the general physiographic and geologic features of the region.

270 **Hague** (Arnold). Early Tertiary volcanoes of the Absaroka Range.
Wash. Geol. Soc., Presidential Address, pp. 25, pls. i–iii; Science, new ser., vol. ix, pp. 425–442, 1899.
Describes the character and occurrence of the volcanics.

271 —— [A geological relief map of the Yellowstone National Park and of the Absaroka Range.]
Abstract: Science, new ser., vol. ix, p. 454 (½ p.) 1899.

272 **Hall** (Christopher Webber). The gneisses, gabbro-schists, and associated rocks of southwestern Minnesota.
U. S. Geol. Surv., Bull., No. 157, 160 pp., 27 pls., 7 figs., 1899.
Describes the occurrence, distribution, and petrographic characters of the rocks.

273 —— [Extent and distribution of the Archæan in Minnesota.]
Abstract: Science, new ser., vol. ix, pp. 412–413, 1899.

274 —— and **Sardeson** (F. W.). Eolian deposits of eastern Minnesota.
Geol. Soc. Am., Bull., vol. x, pp. 349–360, pls. xxxiii–xxxiv. Abstracts: Am. Geol., vol. xxiii, p. 103 (8 l.); Science, new ser., vol. ix, p. 143 (¼ p.), 1899.
Describes the character, occurrence, and origin of the loess formation and dune sands.

275 **Hall** (James) and **Clarke** (John M.). A memoir on the Paleozoic reticulate sponges constituting the family Dictyospongidæ.
N. Y. State Mus., Memoir ii, pp. 350, pls. i–lxx, figs. 1–45, 1898. Reviews: Jour. of Geol., vol. vii, pp. 717–718; Am. Geol., vol. xxiv, pp. 304–305, 1899.
Includes general observations on sponges, the structure, variations, and occurrence of Dictyospongidæ, and description of the genera and species. Includes a bibliography.

276 —— —— A memoir on the Paleozoic reticulate sponges constituting the family Dictyospongidæ. Part I.
N. Y. Geol. Surv., 15th Ann. Rept., vol. ii, pp. 753–890, 47 pls., 17 figs., 1898.

277 —— —— A memoir on the Paleozoic reticulate sponges constituting the family Dictyospongidæ. Part II.
N. Y. Geol. Surv., 16th Ann. Rept., pp. 343–389, pls. xlviii–lxx, figs. 18–45, 1899.

278 **Hamilton** (S. Herbert). Monazite in Delaware County, Pa.
Phil. Acad. Nat. Sci., Proc., 1899, pp. 377–378.
Describes occurrence and crystallographic characters.

279 **Harris** (Gilbert D.). Natchitoches area [Louisiana].
La. State Exp. Stat., Part V, pp. 142–148, pls. xii–xiii, 1899.
Describes the physiography and occurrence of Lower Claiborne deposits.

280 —— The Cretaceous and Lower Eocene faunas of Louisiana.
La. State Exp. Stat., Part V, pp. 289–309, pls. xlix–lv, 1899.

281 **Harris** (Gilbert D.). The Lignitic stage, Part II. Scaphopoda, Gastropoda, Pteropoda, and Cephalopoda.
Am. Pal., Bull., No. 2, pp. 128, 12 pls., 1899.

282 —— and **Veatch** (A. C.). Historical review [of geological literature of Louisiana].
La. State Exp. Stat., Part V, pp. 11–44, 1899.

283 —— —— General geology [of Louisiana].
La. State Exp. Stat., Part V, pp. 52–138, pls. i–x, figs. 2–4, 1899.
Describes the character, occurrence, and distribution of the Cretaceous, Tertiary, and Pleistocene subdivisions, and the occurrence of economic products. Includes geologic map of the State.

284 **Harrison** (J. B.) and **Jukes-Browne** (A. J.). The oceanic deposits of Trinidad [British West Indies].
London Geol. Soc., Quart. Jour., vol. lv, pp. 177–189, 1899.
Describes succession and relations of the Naparima marls.

285 **Haworth** (Erasmus). Mineral resources of Kansas, 1898.
Review: Am. Geol., vol. xxiv, p. 305 (½ p.), 1899.

286 **Hay** (O. P.) On some changes in the names, generic and specific, of certain fossil fishes.
Am. Nat., vol. xxxiii, pp. 783–792, 1899.

287 —— Descriptions of two new species of tortoise from the Tertiary of the United States.
U. S. Nat. Mus., Proc., vol. xxii, pp. 21–24, pls. iv–vi, 1899.

288 —— On one little known and one hitherto unknown species of Saurocephalus.
Am. Jour. Sci., 4th ser., vol. vii, pp. 299–304, 5 figs., 1899.
Discusses character of certain species of Saurodon and Saurocephalus.

289 —— On the nomenclature of certain American fossil invertebrates.
Am. Geol., vol. xxiv, pp. 345–349, 1899.

290 —— On the names of certain North American fossil vertebrates.
Science, new ser., vol. ix, pp. 593–594, 1899.

291 —— Notes on the nomenclature of some North American fossil vertebrates.
Science, new ser., vol. x, pp. 253–254, 1899.

292 —— A census of the fossil vertebrata of North America.
Science, new ser., vol. x, pp. 681–684, 1899.
Gives the number of genera and species of the several groups of the vertebrata.

293 —— On one little known and one hitherto unknown species of Saurocephalus.
Annals and Mag. of Nat. Hist., 7th ser., vol. iii, pp. 480–487, 5 figs., 1899.

294 **Hayes** (C. Willard). Physiography of the Chattanooga district in Tennessee, Georgia, and Alabama.
U. S. Geol. Surv., 19th Ann. Rept., Pt. II, pp. 1–58, pls. iv, fig. 1, 1899.

295 —— A brief reconnaissance of the Tennessee phosphate fields.
U. S. Geol. Surv., 20th Ann. Rept., Pt. VI (cont.), pp. 633–638, 1899.
Describes the occurrence and character of the phosphate deposits.

296 —— Physiography and geology of region adjacent to the Nicaragua Canal route.
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Describes physiographic features, climate, the geology of the region, the processes of rock decay, and the recent geologic history.

297 —— Physiography of the Nicaragua Canal route.
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298 —— The Nicaragua Canal route.
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299 **Heilprin** (Angelo). Geology of the Klondike gold fields.
Pop. Sci. Mo., vol. lv, pp. 300–317, 5 figs., 1899.

300 **Hershey** (Oscar H.). Observations on dirtstorms.
Am. Geol., vol. xxiii, pp. 380–382, 1899.
Describes the occurrence and phenomena accompanying dirtstorms in the Mississippi Valley.

301 —— Origin and age of certain gold "pocket" deposits in northern California. ✓
Am. Geol., vol. xxiv, pp. 38–43, 1899.
Describes the geologic features of the region, and the character, age, and origin of the gold deposits.

302 —— Age and origin of certain gold deposits on the Isthmus of Panama.
Am. Geol., vol. xxiv, pp. 73–77, 1899.
Describes the character, occurrence, and age of the gold-bearing formations.

303 —— Correlations in the Ozark region, a correction.
Am. Geol., vol. xxiv, pp. 190–192, 1899.
Discusses correlation of the Carboniferous and Devonian formations of the region.

304 —— The gold-bearing formations of Stephenson County, Illinois.
Am. Geol., vol. xxiv, pp. 240–244, 1899.
Describes occurrence of gold in the Utica formation of Illinois.

305 **Hershey** (Oscar H.). Archæological notes on central Minnesota.

Am. Geol., vol. xxiv, pp. 283–294, 1899.

Describes glacial phenomena of the region and the occurrence of the implement-bearing beds.

√ 306 —— The Upper Coffee Creek mining district [California].

Min. and Sci. Press, vol. lxxix, p. 689, 1899.

Describes the geologic features and occurrence of gold in the region.

307 **Heydon** (A. Thurston). The headwaters of the Lewis River [British Columbia.]

Min. and Sci. Press, vol. lxxviii, p. 65, 1899.

Describes occurrence of gold in the region.

308 —— Glacial agency in lake formation.

Min. and Sci. Press, vol. lxxviii, p. 265, 1 fig., 1899.

309 **Hidden** (W. E.), **Judd** (J. W.) and. New mode of occurrence of ruby in North Carolina.

See Judd (J. W.) and Hidden (W. E.). No. 367.

310 **Hilgard** (E. W.). The subdivision of genera.

Science, new ser., vol. x, pp. 649–650, 1899.

311 **Hill** (Benj. F.). Notes on a set of rocks from Wyoming, collected by Prof. Wilbur C. Knight, of the University of Wyoming.

School of Mines Quart., vol. xx, pp. 357–364, 5 figs., 1899.

Describes the petrographic characters of the rocks collected.

312 **Hill** (Robert T.). Cuba and Porto Rico, with the other islands of the West Indies; their topography, climate, flora, products, industries, cities, people, political conditions, etc.

New York, The Century Company, 1898, pp. 28–429, 2 maps, 79 plates. Review: Science, new ser., vol. ix, pp. 65–66, 1899.

Includes an account of the physiography and general geologic features of the West Indian Islands.

313 —— The geology and physical geography of Jamaica; study of a type of Antillean development, based upon surveys made for Alexander Agassiz.

Harvard Coll., Mus. of Comp. Zool., Bull., vol. xxxiv, pp. 1–256, 41 pls., 40 figs. Review: Jour. of Geol., vol. vii, pp. 815–824, 1899.

Describes the topographic and geologic features, the occurrence, character, distribution, and fauna of the Cretaceous, Tertiary, and Pleistocene formations and discusses their relation to formations in adjacent islands and the history of the physiographic changes of the West Indies. Contains petrographic notes on igneous rocks by Whitman Cross.

314 —— Porto Rico.

Nat. Geog. Mag., vol. x, pp. 93–112, 13 figs., 1899.

Describes the general physiographic and geologic features of the island.

315 **Hillebrand** (W. F.). Chemical notes on the composition of the roofing slates of eastern New York and western Vermont.
U. S. Geol. Surv., 19th Ann. Rept., Pt. III, pp. 301–305, 1899.

316 —— Mineralogical notes, analyses of tysonite, bastnasite, prosopite, jeffersonite, covellite, etc.
Am. Jour. Sci., 4th ser., vol. vii, pp. 51–57, 1899. Abstract: Am. Geol., vol. xxiii, pp. 324–325 (½ p.), 1899.

317 —— Analysis and composition [of roscoelite].
Am. Jour. Sci., 4th ser., vol. vii, pp. 451–454, 1899. Review: Am. Geol., vol. xxiv, p. 317 (⅛ p.), 1899.
Describes methods of analysis and chemical composition of the material.

318 —— Mineralogical notes, melonite (?), coloradoite, petzite, hessite.
Am, Jour. Sci., 4th ser., vol. viii, pp. 295–298, 1899. Review: Am. Geol., vol. xxiv, p. 321 (8 l.), 1899.

319 **Hills** (Richard Charles). Elmoro folio, Colorado.
U. S. Geol. Surv., Geol. Atlas of U. S., folio No. 58, 1899.
Describes the physiography, the occurrence, and character of the Cretaceous, Neocene, and igneous rocks, and the occurrence of coal and other economic products. Includes topographic and geologic maps, structure, and columnar sections, and special illustrations.

320. **Hobbs** (Walter E.). Some new fossils from eastern Massachusetts.
Am. Geol., vol. xxiii, pp. 109–115, 1 fig., 1899.
Describes character and occurrence of Algonkian and Cambrian rocks, the occurrence of organic remains in the Algonkian strata and the character of a new species from the Middle Cambrian.

321. **Hobbs** (W. H.). The diamond field of the Great Lakes.
Jour. of Geol., vol. vii, pp. 375–388, 1899.
Gives historical sketch of the discovery of diamonds in this region and describes their character, occurrence, and origin.

322 —— Goldschmidtite, a new mineral.
Am. Jour. Sci., 4th ser. vol. vii, pp. 357–364, 1899. Review: Am. Geol., vol. xxiv, p. 182 (⅓ p.) 1899.
Describes the chemical and crystallographic characters of goldschmidtite and sylvanite.

323 —— Spiral fulgurite from Wisconsin.
Am. Jour. Sci., 4th ser., vol. viii, pp. 17–20, 1899.
Describes character and occurrence of the material.

324 **Hoffmann** (G. Christian). An occurrence of polycrase in Canada.
Am. Jour. Sci., 4th ser., vol. vii, p. 243 (½ p.), 1899.
Describes occurrence and chemical composition.

325 **Hollick** (Arthur). Some features of the Staten Island drift, New York.
Abstract: Geol. Soc. Am., Bull., vol. x, pp. 2–4, 1899.
Describes general geology and character of the glacial moraines.

326 **Hollick** (Arthur). The relation between forestry and geology in New Jersey.
Am. Nat., vol. xxxiii, pp. 1-14, 109-116, 1899.

327 —— Geology and geography of the American Association for the Advancement of Science.
Science, new ser., vol. x, pp. 487-491, 1899.
Contains brief abstracts of papers read.

328 —— A report on a collection of fossil plants from northwestern Louisiana.
La. Exp. Stat., Part V, pp. 276-288, pls. 32-48, 1899.

329 —— Notes on deep wells at Princes Bay and Huguenot [Staten Island, New York].
Staten Island Nat. Sci. Assoc., Proc., vol. vii, p. 19, 1899.

330 **Holmes** (Chas.). Coal and coal mining in Michigan.
Abstract: Eng. and Min. Jour., vol. lxviii, pp. 335-336, 1899.
Describes occurrence and character of the coal.

331 **Holmes** (J. A.). Mica deposits in the United States.
U. S. Geol. Surv., 20th Ann. Rept., Pt. VI (cont.), pp. 691-707, 1899.
Abstracts: The Mineral Industry for 1898, vol. vii, pp. 510-511; Science, new ser., vol. ix, p. 142 (¼ p.); Am. Geol., vol. xxiii, pp. 106-108; Eng. and Min. Jour., vol. lxvii, p. 174, 1899.
Describes the occurrence, character, structure, and origin of mica deposits.

332 —— Some geologic conditions favoring water-power developments in the South Atlantic region.
Abstracts: Am. Assoc. Adv. Sci., Proc., vol. xlviii, p. 226 (¼ p.); Science, new ser., vol. x, p. 488 (¼ p.), 1899.

333 **Holmes** (W. H.), **McGee** (W J) and. The geology and archeology of California.
See McGee (W J) and Holmes (W. H.), No. 455.

334 **Hopkins** (T. C.). Clays and clay industries of Pennsylvania. I. Clays of western Pennsylvania (in part).
Pa. State Coll., Ann. Rept. for 1897, appendix, pp. 1-183, 6 pls., 57 figs., 1898.
Describes the general features of clay and their products manufactured in the State.

335 —— Feldspars and kaolins of southeastern Pennsylvania.
Franklin Inst., Jour., vol. cxlviii, pp. 1-31, 1899.
Describes character, occurrence, and distribution in the region.

336 —— Kaolin: Its occurrence, technology, and trade.
The Mineral Industry for 1898, vol. vii, pp. 148-160, 1899.
Describes occurrence and distribution in the United States.

337 —— Feldspar: The occurrence, mining, and uses.
The Mineral Industry for 1898, vol. vii, pp. 262-268, 1899.
Describes occurrence and distribution in the United States.

338 **Hopkins** (T. C.). [Review of "Geology of the Yellowstone National Park, Part II, Descriptive geology, petrography, and paleontology," by Arnold Hague, J. P. Iddings, W. H. Weed, C. D. Walcott, G. H. Girty, T. W. Stanton, and F. H. Knowlton.]

Jour. of Geol., vol. vii, pp. 709–713, 1899.

339 —— The Conshohocken plastic clays [Pennsylvania].

Abstracts: Am. Geol., vol. xxiii, p. 102 (7 l.); Science, new ser., vol. ix, p. 139 (7 l.), 1899.

340 **Hovey** (E. O.). Eleventh winter meeting of the Geological Society of America.

Am. Geol., vol. xxiii, pp. 86–109; Sci. Am. Suppl., vol. xlvii, pp. 19288–19290, 1899.

Gives a summary of the papers read.

341 —— See **Whitfield** (R. P.), No. 730.

342 **Hovey** (Horace C.). The life and work of James Hall, LL. D.

Am. Geol., vol. xxiii, pp. 137–168, pls. iv–v, 1899.

Gives a sketch of his life and work and a list of his publications.

343 **Hubbard** (Lucius L.). Keweenaw Point, with particular reference to the felsites and their associated rocks [Michigan].

Mich. Geol. Surv., vol. vi, Part II, 155 pp., 10 pls., 11 figs., 1898.

Describes the character, occurrence, and relations of the sedimentary and volcanic rocks of the region.

344 **Hunt** (Alfred E.). Corundum in Ontario.

Am. Inst. Min. Engrs., Trans., vol. xxviii, p. 875, 1899.

In discussion of paper by Archibald Blue on the same subject.

I.

345 **Iddings** (Joseph P.). The intrusive rocks of the Gallatin Mountains, Bunsen Peak, and Mount Everts [Yellowstone National Park].

U. S. Geol. Surv., Mon. XXXII, Pt. II., pp. 60–88, pls. xi–xii, 1899.

Describes the petrographic and chemical characters of the rocks.

346 —— The igneous rocks of Electric Peak and Sepulchre Mountain [Yellowstone National Park].

U. S. Geol. Surv. Mon. XXXII, Pt. II, pp. 89–148, pls. xiii–xxii, figs. 1–3, 1899.

Describes the geologic features of the region and the character of the intrusive and volcanic rocks.

347 —— The dissected volcano of Crandall Basin, Wyoming.

U. S. Geol. Surv., Mon. XXXII, Pt. II, pp. 215–268, pls. xxvii–xxxiv, 1899.

Describes the general geology of the region, the occurrence and character of the breccias, the intrusive rocks, and the granular core and dikes. Includes chemical analyses.

348 **Iddings** (Joseph P.). The igneous rocks of the Absaroka Range and Two Ocean Plateau and of outlying portions of the Yellowstone National Park.

U. S. Geol. Surv., Mon. XXXII, Pt. II, pp. 269–325, pl. xxxv, 1899.

Describes the petrographic characters of the breccias, flows, and dike rocks.

349 —— Absarokite-shoshonite-banakite series [Yellowstone National Park].

U. S. Geol. Surv., Mon. XXXII, Pt. II, pp. 326–355, pls. xxxvi–xxxviii, 1899.

Describes petrographic and chemical characters.

350 —— The rhyolites [Yellowstone National Park].

U. S. Geol. Surv., Mon. XXXII, Pt. II, pp. 356–432, pls. xxxix-lvii, fig. 4, 1899.

Describes the megascopical and microscopical characters of the rhyolites and their distribution in the park.

351 —— Recent basalts [Yellowstone National Park].

U. S. Geol. Surv., Mon. XXXII, Pt. II, pp. 433–440, pls. lvii–lix, 1899.

Describes their distribution and petrographic characters.

352 —— [Remarks on the use of the term plutonic plugs.]

Jour. of Geol., vol. vii, pp. 96–97 (½ p.), 1899.

353 —— [Review of "Geological report on Isle Royale, Michigan," by A. C. Lane.]

Jour. of Geol., vol. vii, pp. 718–720, 1899.

354 —— and **Weed** (W. H.). Descriptive geology of the Gallatin Mountains [Yellowstone National Park.]

U. S. Geol. Surv., Mon. XXXII, Pt. II, pp. 1–59, pls. i–x, 1899.

Describes the character and occurrence of the Cambrian, Silurian, Devonian, Carboniferous, Juratrias, and Cretaceous strata and igneous rocks of the region.

355 —— —— Descriptive geology of the northern end of the Teton Range [Yellowstone National Park].

U. S. Geol. Surv., Mon. XXXII, Pt. II, pp. 149–164, pl. xxiii, 1899.

Describes the structure and the character and occurrence of the Cambrian, Silurian, Devonian, Carboniferous, Juratrias, and Cretaceous rocks of the region.

356 **Ingall** (Elfric Drew). Section of mineral statistics and mines. Annual report for 1897.

Can. Geol. Surv., new series, vol. x, Rept. S, 232 pp., 1898.

357 **Irving** (John D.). Some contact phenomena of the Palisade diabase [New Jersey].

School of Mines Quart., vol. xx, pp. 213–223, 3 figs., 1899.

Describes the effects of the intrusive on the diabase and sedimentary rocks.

J.

358 **Jaggar** (T. A., jr.). [Review of "Maryland Geological Survey, vols. i and ii."]
Am. Nat., vol. xxxiii, pp. 277–279, 1899.

359 **Jefferson** (M. S. W.) Beach cusps.
Jour. of Geol., vol. vii, pp. 237–246, 5 figs., 1899.
Describes mode of formation on Massachusetts coast.

360 **Jenney** (W. P.). See **Ward** (L. F.), No. 690.

361 **Johnson** (Charles W.). A new Pliocene Polygyra from Florida.
Nautilus, vol. xiii, pp. 679–681, 1899.
Describes Polygyra caloosaensis n. sp.

362 **Johnson** (W. D.). An unrecognized process in glacial erosion.
Abstracts: Am. Geol., vol. xxiii, pp. 99–100; Science, vol. ix, p. 106 (½ p.), 1899.

363 —— The work of glaciers in high mountains.
Abstract: Science, new ser., vol. ix, pp. 112–113, 1899.

364 —— Subsidence basins of the high plains.
Abstract: Science, new ser., vol. ix, pp. 152–153, 1899.

365 **Jones** (A. W.). New developments of the Mentor beds.
Kan. Acad. Sci., Trans., vol. xvi, pp. 65–66, 1899.
Gives notes on occurrence and fauna in Kansas.

366 **Jones** (T. Rupert) and **Woodward** (Henry). Contributions to fossil Crustacea.
Geol. Mag., dec. iv, vol. vi, pp. 388–395, pl. xv, 1899.
Describes Bellinurus grandævus from Nova Scotia.

367 **Judd** (J. W.) and **Hidden** (W. E.). New mode of occurrence of ruby in North Carolina. With crystallographic notes by J. H. Pratt.
Am. Jour. Sci., 4th ser., vol. viii, pp. 370–381, 1899.
Describes occurrence, character, mineral associates, and crystallography of the material.

367*a* **Jukes-Browne** (A. J.), **Harrison** (J. B.) and. The Oceanic deposits of Trinidad [British West Indies].
See Harrison (J. B.) and Jukes-Browne (A. J.), No. 284.

K.

368 **Kain** (S. W.), **Matthew** (G. F.) and. On artesian and fissure wells in New Brunswick.
See Matthew (G. F.) and Kain (S. W.), No. 473.

369 **Kelvin** (Lord). The age of the earth as an abode fitted for life.
Science, new ser., vol. ix, pp. 665–674 and 704–711, 1899.

370 **Kemp** (James Furman). The titaniferous iron ores of the Adirondacks.

U. S. Geol. Surv., 19th Ann. Rept., Pt. III, pp. 377–422, pls. lv–lxiii, 1899.

Describes the chemical composition, geologic features, local occurrence, and origin of the titaniferous ores of the region. Reviews the general occurrence of these ores in other regions.

371 —— Granites of southern Rhode Island and Connecticut with observations on Atlantic coast granites in general.

Geol. Soc. Am. Bull., vol. x, pp. 361–382, pls. xxxv–xli, 1899. Abstracts: Am. Geol., vol. xxiii, pp. 105–106 (½ p.); Science, new ser., vol. ix, pp. 140–141, 1899.

Describes petrographic character of the Rhode Island granites and the occurrence and character of the granites in the States and Provinces of the Atlantic coast.

372 —— A brief review of the titaniferous magnetites.

School of Mines Quart., vol. xx, pp. 323–356, vol. xxi, pp. 56–65, 1899.

Describes occurrence and chemical characters of the magnetite ores of the United States and other countries.

373 —— Metamorphosed basic dikes in the Manhattan schists, New York City.

Abstracts: Am. Geol., vol. xxiii, p. 105 (6 l.); Science, new ser., vol. ix, p. 140 (½ p.), 1899.

374 —— Eleventh Annual Meeting of the Geological Society of America. December 28, 29, and 30 [1898], New York.

Science, new ser., vol. ix, pp. 100–106, 138–145, 1899.

Contains abstracts of papers presented at the meeting.

375 **Kendall** (J. D.). The silver-lead deposits of the Slocan, British Columbia.

Can. Min. Rev., vol. xviii, pp. 172–186, 42 figs., 1899.

Describes the occurrence and character of the deposits.

376 **Keyes** (Charles R.). American homotaxial equivalents of the original Permian.

Jour. of Geol., vol. vii, pp. 321–341, 1899.

Describes character, occurrence, and faunas of probable Permian strata and discusses their homotaxial relations to the Permian of Europe.

377 —— Some physical aspects of general geological correlation.

Iowa Acad. Sci., Proc., vol. vi, pp. 131–154, pl. vi, 1899.

Discusses methods and criteria to be employed in geologic correlation.

378 —— The Missourian series of the Carboniferous.

Am. Geol., vol. xxiii, pp. 298–316, 1899.

Gives a historical review of the literature on this series, and a description of the character, distribution, and geologic structure of the subdivisions of the series.

379 —— [Review of a review of Wachsmuth and Springer's Monograph on Crinoids, by F. A. Bather.]

Am. Geol., vol. xxiv, pp. 56–58, 1899.

380 **Keyes** (Charles R.). On stratification planes.

Am. Geol., vol. xxiv, pp. 294–300, 1899.

Describes bedding planes, terranal planes, great planes of sedimentation, and erosion planes.

381 —— [Review of "Geology of the Aspen mining district, Colorado," by J. Edward Spurr.]

Am. Geol., vol. xxiv, pp. 307–308, 1899.

382 **Kimball** (James P.). The granites of Carbon County, Montana: A division and glacier field of the Snowy Range.

Am. Geog. Soc. Bull., vol. xxxi, pp. 109–215, pls. i–v, fig. 1, 1899.

Describes the physiographic features of the region and the occurrence of glaciers.

383 **Kindle** (Edward M.). The Devonian and Lower Carboniferous faunas of southern Indiana and central Kentucky.

Am. Pal. Bull., No. 12, 112 pp., 1899.

Describes briefly the stratigraphy of the region and gives notes on the fauna of various sections and a list showing range and distribution of the species. Discusses correlation of the faunas.

384 **King** (Francis H.). Principles and conditions of the movements of ground water.

U. S. Geol. Surv. 19th Ann. Rept., Pt. II, pp. 59–294, pls. vi–xvi, figs. 2–53, 1899.

385 **King** (Helen Dean). Edward Drinker Cope.

Am. Geol., vol. xxiii, pp. 1–41, pl. i, 1899.

Gives a brief sketch of Professor Cope's life and bibliographic list of his publications.

386 **Knapp** (S. A.). Occurrence and recovery of sodium carbonate in the Great Basin.

The Mineral Industry for 1898, vol. vii, pp. 626–634, 1899.

387 **Knight** (Wilbur C.). The Nebraska Permian.

Jour. of Geol., vol. vii, pp. 357–374, 1899.

Describes character, occurrence, and faunas of the Kansas and Nebraska Permian strata.

388 —— Some new data for converting geological time into years.

Science, new ser., vol. x, pp. 607–608, 1899.

Describes the method adopted of estimating the time of the erosion of certain Miocene beds in Wyoming.

389 —— and **Barbour** (E. H.). The discovery of new invertebrates in the Dinosaur beds of Wyoming.

See Barbour (E. H.) and Knight (W. C.), No. 31.

390 —— and **Slosson** (E. E.). The oil fields of Crook and Uinta counties, Wyoming.

Wyoming Univ. School of Mines, Bull., No. 3, 1899. (Not seen.)

391 **Knowlton** (Frank Hall). Report on some fossil wood from the Richmond Basin, Virginia.

U. S. Geol. Surv., 19th Ann. Rept., Pt. II, pp. 516–519, pl. lii, 1899.

Describes two species of Araucarioxylon.

392 —— Fossil flora [Yellowstone National Park].

U. S. Geol. Surv., Mon. XXXII, Pt. II, pp. 651–882, pls. lxxvii–cxxi, 1899.

Describes the fossil flora collected in the region and their relations, and the occurrence and character of the fossil forests.

393 —— Catalogue of Cretaceous and Tertiary plants of North America.

Review: Am. Jour. Sci., 4th ser., vol. vii, p. 168 (½ p.), 1899.

See Bibliography and Index for 1898, No. 450.

394 —— See **Ward** (L. F.). No. 690.

395 **Kümmel** (Henry B.). The extension of the Newark system of rocks.

N. J. Geol. Surv., Rept. for 1898, pp. 43–57, pl. ii, figs. 9–10, 1899. Abstracts: Am. Geol., vol. xxiii, p. 83 (½ p.); Science, new ser., vol. ix, pp. 102–103, 1899.

Describes the extension of the Newark system into New York.

396 —— The Newark rocks of New Jersey and New York.

Jour. of Geol., vol. vii, pp. 23–52, 4 figs., 1899.

Describes the occurrence, character, structure, and relation of the Newark sedimentary and trap rocks of the region. Includes geologic maps.

397 **Kuntze** (Otto). On the occurrence of quenstedtite near Montpelier, Iowa.

Am. Geol., vol. xxiii, pp. 119–121, 1899.

Describes occurrence, mode of formation, and chemical character.

398 **Kunz** (George F.). Native silver in North Carolina.

Am. Jour. Sci., 4th ser., vol. vii, pp. 242–243, 1899.

L.

399 **Ladd** (George E.). A preliminary report on a part of the clays of Georgia.

Ga. Geol. Surv. Bull., No. 6A, 204 pp., 28 pls., 1898.

Describes properties, occurrence, and distribution of clay deposits in Georgia.

400 —— Notes on the Cretaceous and associated clays of middle Georgia.

Am. Geol., vol. xxiii, pp. 240–249, 1899.

Describes the relations of the Cretaceous and Tertiary strata and character of the clays of the Potomac formation.

401 **Lakes** (Arthur). The Mother Lode of California. ✓
Mines and Minerals, vol. xix, pp. 248-250, 5 figs., 1899.
Describes the structure and occurrence of the veins.

402 —— Boulder region, Colorado.
Mines and Minerals, vol. xix, pp. 252-253, 1899.
General notes on the region.

403 —— Placer mining in California. ✓
Mines and Minerals, vol. xix, pp. 297-298, 2 figs., 1899.

404 —— Natural gas in Colorado.
Mines and Minerals, vol. xix, pp. 339-340, 1899.
Describes occurrence and origin.

405 —— New Almaden mines of Santa Clara County, California. ✓
Mines and Minerals, vol. xix, pp. 346-349, 3 figs., 1899.

406 —— Observations on some prospects and mines around Breckenridge, South Park, Colorado.
Mines and Minerals, vol. xix, pp. 440-441, 2 figs., 1899.
Contains notes on the geology of the region.

407 —— California gold mines. ✓
Mines and Minerals, vol. xix, pp. 444-446, 6 figs., 1899.

408 —— Coal fields of Colorado.
Mines and Minerals, vol. xix, pp. 541-543, 4 figs., 1899.

409 —— California asphaltum. ✓
Mines and Minerals, vol. xx, pp. 108-109, 4 figs., 1899.
Describes occurrence and character of the material.

410 —— Grand River coal field of Colorado.
Mines and Minerals, vol. xx, pp. 110-111, 3 figs., 1899.
Describes geological occurrence of coal in this region.

411 —— Description of Raven Hill, Cripple Creek, and its ore deposits [Colorado].
Mines and Minerals, vol. xx, pp. 154-155, 1 fig., 1899.

412 —— Calaveras County mines [California]. ✓
Mines and Minerals, vol. xx, pp. 198-200, 6 figs., 1899.

413 **Lambe** (Lawrence M.). A revision of the genera and species of Canadian Paleozoic corals. The Madreporaria perforata and Alcyonaria.
Can. Geol. Surv., Cont. to Can. Pal., vol. iv, Pt. I, 96 pp., 5 pls., 1899.

414 —— On some species of Canadian Paleozoic corals.
Ottawa Nat., vol. xii, pp. 217-226, 237-258, 1899.
Describes structural details not given in original descriptions, and a supposed new species.

415 **Lambe** (Lawrence M.). On reptilian remains from the Cretaceous of northwestern Canada.

Ottawa Nat., vol. xiii, pp. 68–70, 1899.

Contains brief notes on the fossils collected.

416 —— Notes on a stromatoporoid from the Hudson River formation of Ontario.

Ottawa Nat., vol. xiii, pp. 170–171, 1399.

Contains notes on Labechia huronensis Billings.

417 **Lane** (Alfred C.). Geological report on Isle Royale, Michigan.

Mich. Geol. Surv., vol. vi, Pt. I, 281 pp., 16 pls., 29 figs., 1898.

Describes the structure, occurrence and character of the sedimentary and igneous rocks and the occurrence of diabase intrusives in the Huronian.

418 —— Water resources of the Lower Peninsula of Michigan.

U. S. Geol. Surv., Water-Supply Paper No. 30, 97 pp., 7 pls., 14 figs, 1899.

Describes the water supply of the region and the general physiographic and geologic features.

419 —— Lower Michigan mineral waters.

U. S. Geol. Surv., Water-Supply Paper No. 31, 97 pp., 4 pls., 2 figs., 1899.

Describes chemical composition and occurrence.

420 —— Note on a method of stream capture.

Geol. Soc. Am., Bull., vol. x, pp. 12–15, fig. 1, 1899.

Describes occurrence in Michigan.

421 —— Magmatic differentiation in rocks of the copper-bearing series.

Abstract: Geol. Soc. Am., Bull., vol. x, pp. 15–18, 1899.

422 **Lavagnino** (G.). The Old Telegraph mine, Utah.

Min. and Sci. Press, vol. lxxviii, p. 589, 1899.

Describes occurrence of gold and silver.

423 **Le Conte** (Joseph). The Ozarkian and its significance in theoretical geology.

Jour. of Geol., vol. vii, pp. 525–544, 1899.

Describes the events of the Ozarkian epoch immediately preceding the Glacial epoch, the origin of glacial phenomena, and the use of the term Psychozoic.

424 —— The Ozarkian and its significance in theoretic geology.

Abstracts: Am. Assoc. Adv. Sci. Proc., vol. xlviii, p. 229 (½ p.); Science, new ser., vol. x, p. 490 (½ p.), 1899.

425 **Lee** (Harry A.). The asphalt deposits of Middle Park, Colorado.

Eng. and Min. Jour., vol. lxvii, p. 468, 1899.

426 **Lee** (W. T.). [Review of "The University Geological Survey of Kansas, vol. iv, Paleontology, Part I, Upper Cretaceous" by S. W. Williston.]

Jour. of Geol., vol. vii, pp. 100–101, 1899.

427 **Lee** (W. T.). [Review of "Bulletin of the American Museum of Natural History, vol. x."]
Jour. of Geol., vol. vii, pp. 316–317, 1899.

428 —— [Review of "Geology of the Aspen mining district, Colorado," by J. E. Spurr.]
Jour. of Geol., vol. vii, pp. 721–722, 1899.

429 **Leith** (C. K.). Summaries of current pre-Cambrian literature.
Jour. of Geol., vol. vii, pp. 190–205, 406–425, 702–708, 790–812, 1899.

430 **Leonard** (A. G.), **Bain** (H. F.) and. Middle Coal Measures of the western interior coal fields.
See Bain (H. F.) and Leonard (A. G.), No. 28.

431 **Leverett** (Frank). The Illinois Glacial lobe.
U. S. Geol. Surv., Mon. XXXVIII, 817 pp., 24 pls., 9 figs., 1899.
Describes the physiography, the character, occurrence, and distribution of the glacial deposits and the water supply of the State.

432 —— Wells of northern Indiana.
U. S. Geol. Surv., Water-Supply Paper No. 21, 82 pp., 2 pls., 1899.
Abstract: Am. Geol., vol. xxiii, p. 385 (½ p.), 1899.
Describes character and distribution of the glacial deposits and gives well data.

433 —— Wells of southern Indiana.
U. S. Geol. Surv., Water-Supply Paper No. 26, 64 pp., 1899.
Gives data regarding the wells of the region.

434 —— The lower rapids of the Mississippi River.
Jour. of Geol., vol. vii, pp. 1–22, 2 figs., 1899; Iowa Acad. Sci. Proc., vol. vi, pp. 74–93, 1 fig., 1899.
Describes the drainage of the Upper Mississippi Valley during the Glacial epoch.

435 —— Glacial phenomena of central Ohio.
Abstract: Science, new ser., vol. x, p. 487–488 (½ p.), 1899.

436 **Lewinson-Lessing** (F.). Classification of rocks and differentiation of magmas.
Review: Am. Geol., vol. xxiii, pp. 346–369, 1899.

437 **Lindgren** (Waldemar). The copper deposits of the "Seven Devils," Idaho.
Min. and Sci. Press, vol. lxxviii, p. 125, 1899.
Describes general geologic features and occurrence of copper ores in the region.

438 **Logan** (W. N.). Contributions to the paleontology of the Upper Cretaceous.
Field Col. Mus., Geol. ser., vol. i, pp. 207–216, pls. 22–26, 1899.
Describes material from the Cretaceous of Kansas.

439 **Logan** (W. N.). A discussion and correlation of certain subd visions of the Colorado formation.

Jour. of Geol., vol. vii, pp. 83–91, 1899.

Describes the Colorado formation of the Kansan area, and discuss its correlation with other regions.

440 —— Some additions to the Cretaceous invertebrates of Kansas.

Kansas Univ. Quart., vol. viii, pp. 87–98, pls. xx–xxiii, 1899.

441 —— [Review of "The Cretaceous of the Black Hills as indicate by the fossil plants," by Lester F. Ward, with the collabora tion of Walter P. Jenney, William M. Fontaine, and F. H Knowlton.]

Jour. of Geol., vol. vii, pp. 814–815, 1899.

442 **Lord** (Edwin C. E.). Petrographic report on rocks from th United States–Mexico boundary.

U. S. Nat. Mus. Proc., vol. xxi, pp. 773–782, with map, 1899.

Describes petrographic characters of rocks collected by the Inter national Boundary Commission.

443 **Lucas** (F. A.). Rock salt in Louisiana.

Abstract: Eng. and Min. Jour., vol. lxviii, pp. 577–578, 1899.

444 —— The fossil bison of North America.

U. S. Nat. Mus. Proc., vol. xxi, pp. 755–771, pls. lxv–lxxxvi Review: Am. Geol., vol. xxiii, p. 385 (5 l.), 1899.

445 —— A new snake from the Eocene of Alabama.

U. S. Nat. Mus. Proc., vol. xxi, pp. 637–638, pls. xlv–xlvi, 1899 Published in 1898.

Describes Pterosphenus schucherti.

446 —— The characters of Bison occidentalis, the fossil bison o Kansas and Alaska.

Kan. Univ. Quart., vol. viii, pp. 17–18, 1899.

Compares this species with B. antiquus.

447 **Ludloff** (K.). The discovery of gold-bearing conglomerate in British Columbia.

Min. and Sci. Press, vol. lxxix, p. 692, 1899.

Describes occurrence in Frazer River region.

448 **Luquer** (L. M.). Minerals in rock sections: The practical methods of identifying minerals in rock section with microscope; especially arranged for students in technical and scientific schools.

D. Van Nostrand Company, N. Y., 1898. Review: Am. Geol., vol. xxiv, pp. 120–121, 1899.

449 **Luther** (D. D.). The brine springs and salt wells of the State o New York and the geology of the salt district.

N. Y. Geol. Surv., 16th Ann. Rept., pp. 171–226, 4 pls., 6 figs. (an geological map), 1899.

Describes the occurrence of salt and the character and occurrence o the subdivision of the Silurian and Devonian in the salt district.

M.

450 **Macbride** (T. H.). Geology of Humboldt County [Iowa].

Iowa Geol. Surv., vol. ix, pp. 113-154, figs. 12-16 and geologic map, 1899.

Describes the physiography, the character and occurrence of the Carboniferous and Pleistocene deposits, and the occurrence of economic products in the county.

451 **McCallie** (S. W.). A preliminary report on the artesian well system of Georgia.

Ga. Geol. Surv., Bull. No. 7, pp. 1-214, pls. i-vii, figs. 1-22, 1898. Review: Jour. of Geol., vol. vii, p. 722, (½ p.) 1899.

Gives sections of numerous artesian wells of Georgia.

452 —— Gold deposits of Georgia. Paper read before the International Gold Mining Convention, Denver, Colo., July 8, 1897. 17 pp. 1 map. 1898. Not seen.

453 **McGee** (W J). The Pre-Lafayette (Tennessean) base-level.

Abstracts: Am. Assoc. Adv. Sci. Proc., vol. xlviii., p. 227 (7 l.); Science, new ser., vol. x, p. 489 (12 l.), 1899.

454 —— [Review of "Cuba and Porto Rico," by R. T. Hill.]

Science, new ser., vol. ix, pp. 65-66, 1899.

455 —— and **Holmes** (W. H.). The geology and archeology of California.

Abstracts: Am. Geol., vol. xxiii, pp. 96-99; Science, new ser., vol. ix, pp. 104-105; Sci. Am. Suppl., vol. xlvii, p. 19313, 1899.

456 **McInnes** (William). Report on the geology of the area covered by the Seine River and Lake Shebandowan map sheets, comprising portions of Rainy River and Thunder Bay districts, Ontario.

Can. Geol. Surv., new ser., vol. x, Rept. H, 65 pp., 2 maps, 3 pls., 1899.

Describes the physiography and drainage, the character and occurrence of the Algonkian, Cambrian, and Glacial deposits, and the occurrence of iron and gold.

457 **MacKellar** (Peter). The gold-bearing veins of Bag Bay, near Lake of the Woods.

Can. Min. Rev., vol. xviii, pp. 144-147, 2 figs. Abstracts: Science, new ser., vol. ix, p. 144 (10 l.); Am. Geol., vol. xxiii, p. 104 (7 l.), 1899.

458 **Maguire** (Don). Central Idaho gold field.

Mines and Minerals, vol. xix, pp. 289-291, 2 figs., 1899.

Describes occurrence of gold.

459 —— Snake River gold fields of Idaho.

Mines and Minerals, vol. xx, pp. 56-58, 1 fig., 1899.

460 **Manson** (Marsden). The laws of climatic evolution.

Am. Geol., vol. xxiii, pp. 44-57, 1899.

Gives a review of climatic conditions and a summary of the theories of climatic evolution.

461 **Manson** (Marsden). The evolution of climates.

Am. Geol., vol. xxiv, pp. 93–120, 1899.

Reviews several theories as to the cause of glacial epochs, gives a general statement of the problem, and discusses the evidences of tropical glaciation.

462 —— The evolution of climates (concluded).

Am. Geol., vol. xxiv, pp. 157–180, pp. 205–209, pl. xi, 1899.

Discusses the origin and development of climates, and the influence of the lava flows of the Columbia plain on the existing climate.

463 **Marsh** (O. C.). Footprints of Jurassic Dinosaurs.

Am. Jour. Sci., 4th ser., vol. vii, pp. 229–232, 3 figs., pl. v, 1899.

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464 —— Note on a Bridger Eocene carnivore. (Note prepared by J. L. Wortman.)

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465 —— The origin of mammals.

Geol. Mag., dec. iv, vol. vi, pp. 13–16, 1899.

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469 —— A Paleozoic terrane beneath the Cambrian.

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470 —— A new Cambrian trilobite.

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Am. Geol., vol. xxiii, pp. 59–61, 1899.

472 —— [Review of preliminary notice of the Etcheminian fauna of Newfoundland.]

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477 —— The Kadiak Islands. The Alaska Peninsula and the Aleutian Islands [Alaska].

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478 —— **Schrader** (F. C.) and. [Notes on the geology of portions of Alaska].

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Reviews "The Lower Cretaceous Gryphæas of the Texas region" and "Geology of the Edwards Plateau and Rio Grande Plain adjacent to Austin and San Antonio, Texas, with reference to the occurrence of underground waters," by R. T. Hill and T. Wayland Vaughan.

587 —— A consideration of the interpretation of unusual events in geologic records illustrated by recent examples.
Abstracts: Am. Assoc. Adv. Sci., Proc., vol. xlviii, p. 227 (½ p.); Science, new ser., vol. x, p. 489 (½ p.), 1899.

588 —— [Review of "The Lower Cretaceous Gryphæas of the Texas region," by R. T. Hill and T. W. Vaughan.]
Science, new ser., vol. ix, pp. 110–111, 1899.

589 **Slichter** (C. S.). Theoretical investigations of the motion of ground waters.
U. S. Geol. Surv., 19th Ann. Rept., Pt. II, pp. 295–384, pl. xvii, figs. 54–89, 1899.

590 **Slocum** (Charles E.). The relative ages of the Maumee Glacial lake and the Niagara gorges.
Abstracts: Am. Assoc. Adv. Sci., Proc., vol. xlviii, pp. 227–228 (½ p.); Science, new ser., vol. x, p. 499 (½ p.), 1899.

591 **Slosson** (E. E.), **Knight** (W. C.) and. The oil fields of Crook and Uinta counties, Wyoming.
See Knight (W. C.) and Slosson (E. E.), No. 390.

592 **Smith** (Alva J.). Fusulina cylindrica shell structure.
Kan. Acad. Sci., Trans., pp. 64–65, figs. 1–4, 1899.

593 **Smith** (G. O.), **Tower** (G. W., jr.) and. Geology and mining industry of the Tintic district, Utah.
See Tower (G. W., jr.) and Smith (G. O.), No. 632.

594 —— **Willis** (B.) and. Tacoma folio, Washington.
See Willis (B.) and Smith (G. O.), No. 746.

595 **Smith** (W. S. Tangier). Some aspects of erosion in relation to the theory of the peneplain.
Univ. of Cal., Dept. of Geol., Bull., vol. ii, pp. 155–178, 1899.
Discusses objections to the theory of peneplains and a modification of the use of the term.

596 **Smyth** (C. H., jr.). Geology of the Adirondack region.
Appalachia, vol. ix, No. 1, pp. 44–51, 1899.
Describes general character and occurrence of the igneous rocks.

597 **Smyth** (H. L.), **Clements** (J. M.) and. The Crystal Falls iron-bearing district of Michigan.
See Clements (J. M.) and Smyth (H. L.), No. 105.

598 **Springer** (Frank). Notice of a new discovery concerning Uintacrinus.
Am. Geol., vol. xxiv, p. 92, 1899.
Describes peculiar features of Uintacrinus.

599 **Spurr** (Josiah Edward). Lakes Iliamna and Clark. The Nushagak River. The coast from Bristol Bay to the Yukon. The Kuskokwim drainage area. From the Yukon mouth to Point Barrow. The Kowak River, the Noatak River.
U. S. Geol. Surv., Expl. in Alaska, pp. 118–129, 1899.
Notes on routes of travel and occurrence of gold.

600 —— Geology of the Aspen mining district, Colorado.
Review: Am. Geol., vol. xxiv, pp. 307–308, 1899.
See Bibliography and Index for 1898, No. 739*a*.

601 —— and **Post** (W. S.). Report on the Kuskokwim expedition [Alaska].
U. S. Geol. Surv., Expl. in Alaska, pp. 28–39, 1899.
Describes the physiography, the occurrence of volcanic, Juratrias, and Tertiary rocks, and the occurrence of gold-bearing gravels.

602 **Squier** (G. H.). Studies in the driftless region of Wisconsin.
Jour. of Geol., vol. vii, pp. 79–82, 1899.
Describes evidences of glacial action in the region.

603 **Stanton** (Timothy W.). Mesozoic fossils [Yellowstone National Park].
U. S. Geol. Surv., Mon. XXXII, Pt. II, pp. 600–650, pls. lxxii–lxxvi, 1899.
Describes the relations of the faunas of the several horizons and the characters of the fossils collected.

604 **Stearns** (Robert E. C.). Description of a species of Actæon from the Quaternary bluffs at Spanish Bight, San Diego, Cal.
U. S. Nat. Mus., Proc., vol. xxi, pp. 297–299, 1 fig., 1899. Published in 1898.

605 **Stevenson** (John J.). Our society.
Geol. Soc. Am. Bull., vol. x, pp. 83–98, 1899.
Gives a historical sketch of the Geological Society of America and an account of the general results of several official geological surveys.

606 —— [Review of "West Virginia Geological Survey, vol. i, 1899."]
Science, new ser., vol. x, pp. 652–653, 1899.

607 **Stevenson** (John J.). The section at Schoharie, N. Y.

Abstract: Science, new ser., vol. x, pp. 735–736, 1899.

Compares the section with others of the Appalachians in Pennsylvania and Virginia.

608 **Stewart** (Alban). A preliminary description of the opercular and other cranial bones of Xiphactinus Leidy.

Kans. Univ. Quart., vol. viii, pp. 19–21, 1899.

Describes material in the museum of the University of Kansas.

609 —— Pachyrhizodus minimus, a new species of fish from the Cretaceous of Kansas.

Kan. Univ. Quart., vol. viii, pp. 37–38, fig. 1, 1899.

Describes material from Logan County, Kansas.

610 —— Notice of three new Cretaceous fishes, with remarks on the Saurodontidæ Cope.

Kan. Univ. Quart., vol. viii., pp. 107–112, 1899.

611 —— Notes on the osteology of Anogmius polymicrodus Stewart.

Kan. Univ. Quart., vol. viii., pp. 117–121, pl. xxxi, 1899.

612 —— Leptichthys, a new genus of fishes from the Cretaceous of Kansas.

Am. Geol., vol. xxiv, pp. 78–79, 1899.

Describes the genus and one species.

613 **Stone** (George H.). The glacial gravels of Maine and their associated deposits.

U. S. Geol. Surv., Mon. XXXIV, 499 pp., 52 pls., 36 figs., 1899.

Describes the superficial deposits and the character, distribution, classification, and genesis of the glacial gravels. Contains a discussion of the glaciation of the Rocky Mountains.

614 —— Granitic breccias of Grizzly Peak, Cal.

Am. Jour. Sci., 4th ser., vol. vii, pp. 184–186, 1899.

Describes the character and origin of the breccias.

615 —— Dry gold placers of the arid regions.

Mines and Minerals, vol. xix, pp. 397–399, 1899.

Describes occurrence and methods of mining.

T.

616 **Taff** (Joseph A.). Geology of the McAlester-Lehigh coal field, Indian Territory. Accompanied by a report on the fossil plants by David White, and a report on the Paleozoic invertebrate fossils by George H. Girty.

U. S. Geol. Surv., 19th Ann. Rept., Pt. III, pp. 423–593, pls. lxiv–lxxii, figs. 77–80, 1899.

Describes the physiographic features, character, and structure of the Carboniferous strata, and the occurrence, distribution, and character of the coals of the region.

617 **Taff** (Joseph A.). Albertite-like asphalt in the Choctaw Nation, Indian Territory.

Am. Jour. Sci., 4th ser., vol. viii, pp. 219–224, 1899. Review: Am. Geol., vol. xxiv, p. 318 (¼ p.), 1899.

Describes character and occurrence of the material and the geologic features of the region.

618 —— Changes in the Canadian River in western Choctaw Nation, Indian Territory.

Abstract: Science, new ser., vol. x, p. 26 (¼ p.), 1899.

619 **Tarr** (Ralph S.). Physical geography of New York State. Part VII. The Great Lakes and Niagara.

Am. Geog. Soc. Bull., vol. xxxi, pp. 101–117 (4 figs.), pp. 217–235 (10 figs.), 315–343 (21 figs.), 1899.

Describes the physiographic and glacial geology of the Great Lakes region and includes a bibliography.

620 —— Physical geography of New York State. Part IX. The shore lines.

Am. Geog. Soc. Bull., vol. xxxi, pp. 417–443, 22 figs., 1899.

621 **Taylor** (Frank B.). The great ice dams of Lakes Maumee, Whittlesey, and Warren.

Am. Geol., vol. xxiv, pp. 6–38, pls. ii–iii, 1899. Review: Jour. of Geol., vol. vii, pp. 621–623, 1899.

Describes glacial phenomena in the Great Lakes region.

622 —— The Galt moraine and associated drainage.

Abstracts: Am. Assoc. Adv. Sci. Proc., vol. 48, p. 228 (¾ p.); Science, new ser., vol. x, pp. 489–490 (½ p.), 1899.

623 **Teller** (Edgar S.), **Monroe** (Charles E.) and. The fauna of the Devonian formation at Milwaukee, Wisconsin.

See Monroe (C. E.) and Teller (E. E.), No. 490.

624 **Todd** (James Edward). The moraines of southeastern South Dakota and their attendant deposits.

U. S. Geol. Surv., Bull. No. 158, 165 pp., 27 pls., 31 figs., 1899.

Describes the occurrence and characters of the moraines, loess, and terraces of the region.

625 —— New light on the drift in South Dakota.

Iowa Acad. Sci., Proc., vol. vi, pp. 122–130, pl. v, 1899.

Describes glacial deposits and their relations and fauna in South Dakota.

626 —— The geology of Hubbard County and northwestern portion of Cass County [Minnesota].

Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. 4, pp. 82–97, pls. lix, D–E, 1899.

Describes the glacial geology of the region.

627 **Todd** (James Edward). The geology of Norman and Polk counties [Minnesota].

Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 98–116, pl. lxii, F–I, fig. 9, 1899.

Describes the physiography and glacial history of the county.

628 —— The geology of Marshall, Roseau, and Kittson counties [Minnesota].

Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 117–130, pl. lxiii, and J, fig. 10, 1899.

Describes the glacial features of the region.

629 —— The geology of Beltrami County [Minnesota].

Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 131–155, pl. lxiv, and K–M, figs. 11–15, 1899.

Describes the physiography and occurrence of Archean rocks and glacial deposits of the region.

630 **Tolman** (C. F., jr.). The carbon dioxide of the ocean and its relation to the carbon dioxide of the atmosphere.

Jour. of Geol., vol. vii, pp. 585–618, 1899.

631 —— [Review of "The influence of the carbonic acid of the air upon the temperature of the ground," by Svante Arrhenius.]

Jour. of Geol., vol. vii, pp. 623–625, 1899.

632 **Tower** (George Warren, jr.) and **Smith** (George Otis). Geology and mining industry of the Tintic district, Utah.

U. S. Geol. Surv., 19th Ann. Rept., Pt. III, pp. 601–767, pls. lxxiii–xcix, figs. 81–92, 1899.

Describes the occurrence and character of the Cambrian and Carboniferous strata and igneous rocks, the volcanic and metamorphic phenomena, and the occurrence and origin of the ore bodies.

633 **Turner** (Henry W.). Granitic rocks of the Sierra Nevada.

Jour. of Geol., vol. vii, pp. 141–162, 1 fig., 1899. Abstract: Am. Nat., vol. xxxiii, p. 552, 1899.

Describes occurrence and petrographic and chemical character of biotite-granite, granodiorite, quartz-monzonite, soda-granite, and aplite.

634 —— Replacement ore deposits in the Sierra Nevada.

Jour. of Geol., vol. vii, pp. 389–400, pl. v, 1899.

Describes character and occurrence of certain ore bodies in California and the petrographic character of associated rocks.

635 —— Rock-forming biotites and amphibolites. With analyses by W. F. Hillebrand, H. N. Stokes, and William Valentine.

Am. Jour. Sci., 4th ser., vol. vii, pp. 294–298. Review: Am. Geol., vol. xxiv, p. 181 (½ p.), 1899.

Describes general character of the materials, and gives chemical analyses.

636 **Turner** (Henry W.). The occurrence of roscoelite.

Am. Jour. Sci., 4th ser., vol. vii, pp. 455–458. Reviews: Min. and Sci. Press, lxxix, p. 93, 1899; Am. Geol., vol. xxiv, p. 318 (½ p.), 1899.

Describes occurrence and geologic relations of the associated rocks.

637 —— The geology of Yosemite National Park.

Abstracts: Am. Geol., vol. xxiii, pp. 100–101: Science, new ser., vol. ix, p. 106 (9 l.), 1899.

638 —— The occurrence and origin of diamonds in California.

Am. Geol., vol. xxiii, pp. 182–191; Min. and Sci. Press, vol. lxxviii, pp. 586, 613, 1899.

Gives list of localities where diamonds have been found in California, and reviews recent literature on the origin of diamonds.

639 —— and **Ransome** (F. L.). Big Trees folio, California.

U. S. Geol. Surv., Geol. Atlas of U. S., folio No. 51, 1898.

Describes the physiographic features, the occurrence and character of the Bed-rock and Superjacent series, which include both sedimentary and igneous rocks, and the occurrence of the auriferous gravels.

640 **Tyrrell** (J. Burr). Glacial phenomena in the Canadian Yukon district.

Geol. Soc. Am. Bull., vol. x, pp. 193–198, pl. xxi, 1899.

Describes glacial phenomena of the region.

641 —— Gold mining in the Klondike district [Alaska].

Abstracts: Am. Geol., vol. xxiii, p. 102 (8 l.); Science, new ser., vol. ix, p. 106 (8 l.); Eng. and Min. Jour., vol. lxvii, p. 116, 1899.

U.

642 **Udden** (Johan August). Geology of Muscatine County [Iowa].

Iowa Geol. Surv., vol. ix, pp. 251–380, pls. v–vii, figs. 30–40, and geologic map, 1899.

Describes the physiographic features, the character and occurrence of the Silurian, Devonian, Carboniferous, and Pleistocene subdivisions, and the occurrence of economic products.

643 —— The Sweetland Creek beds.

Jour. of Geol., vol. vii, pp. 65–78, 1899.

Gives several sections of the beds and describes their distribution, structural relations, and fauna.

644 —— Dipterus in the American Middle Devonian.

Jour. of Geol., vol. vii, pp. 494–495, 1 fig., 1899.

Describes occurrence of the Dipterus calvini Eastman in the Devonian of Iowa.

645 —— Some Cretaceous drift pebbles in northern Iowa.

Am. Geol., vol. xxiv, pp. 389–390, 1899.

646 —— Diatomaceous earth in Muscatine County [Iowa].

Iowa Acad. Sci. Proc., vol. vi, pp. 53 (½ p.), 1899.

Brief note on occurrence.

647 **Udden** (Johan August). The Pine Creek conglomerate [Iowa].
Iowa Acad. Sci., vol. vi, pp. 54–56, 1899.
Describes occurrence and discusses age.

648 **Upham** (Warren). The geology of Aitkin County [Minnesota].
Minn. Geol. and Nat. Hist. Surv., Final Rep., vol. iv., pp. 25–54, pl. lxii, figs. 2–6, 1899.
Describes the physiography, occurrence of eruptive and Cretaceous rocks, and glacial history of the county.

649 —— The geology of Cass County and of the part of Crow Wing County northwest of the Mississippi River [Minnesota].
Minn. Geol. and Nat. Hist. Surv., Final Rep., vol. iv, pp. 55–81, figs. 7–8, 1899.
Describes the physiographic and geologic features and glacial history of the county.

650 —— Geology of the region around Red Lake and southward to White Earth [Minnesota].
Minn. Geol. and Nat. Hist. Surv., Final Rept., vol. iv, pp. 155–165, pl. VV, 1899.
Describes physiographic and glacial features of the region.

651 —— Evidence of epeiroganic movements causing and terminating the Ice age.
Geol. Soc. Am. Bull., vol. x, pp. 5–10, 1899.
Discusses evidences of high elevation and late glacial depression and its termination of the Ice age.

652 —— Glacial and modified drift in Minneapolis, Minn.
Abstracts: Am. Assoc. Adv. Sci., Proc., vol. xlviii, p. 229 (½ p.); Science, new ser., vol. x, p. 490 (¼ p.), 1899.

653 —— Greatest area and thickness of the North American ice sheet.
Abstracts: Am. Assoc. Adv. Sci., Proc., vol. xlviii, pp. 230–231; Science, new ser., vol. x, p. 491, 1899.

654 —— [Review of "South Dakota Geological Survey Bull. No. 2"].
Am. Geol., vol. xxiii, p. 192 (¾ p.), 1899.

655 —— [Review of "The loess of aqueous origin," by B. Shimek].
Am. Geol., vol. xxiii, pp. 192–193, 1899.

656 —— Modified drift in the Champlain epoch.
Am. Geol., vol. xxiii, pp. 319–324, 1899.
Describes occurrence, character, and classification of drift deposits.

657 —— [Review of "Iron making in Alabama," by W. B. Phillips.]
Am. Geol., vol. xxiii, pp. 328–329 (⅓ p.), 1899.

658 —— [Review of "A guide to the study of the geological collections of the New York State Museum," by F. J. H. Merrill.]
Am. Geol., vol. xxiii, p. 329 (⅓ p.), 1899.

659 **Upham** (Warren). Englacial drift in the Mississippi Basin.
Am. Geol., vol. xxiii, pp. 369–374, 1899.
Describes occurrence and character of englacial drift in Hudson Bay and Upper Mississippi Valley regions.

660 —— [Review of "Summary report of the Geological Survey department of Canada for the year 1898," by G. M. Dawson.]
Am. Geol., vol. xxiii, pp. 384–385, 1899.

661 —— [Review of "Wells of northern Indiana," by Frank Leverett.]
Am. Geol., vol. xxiii, p. 385 (⅓ p.), 1899.

662 —— [Review of "The fossil bison of North America," by Frederick A. Lucas.]
Am. Geol., vol. xxiii, p. 385 (5 l.), 1899.

663 —— [Review of "West Virginia Geological Survey, vol. i," by I. C. White.]
Am. Geol., vol. xxiii, pp. 387–389, 1899.

664 —— Glacial history of the New England Islands, Cape Cod, and Long Island.
Am. Geol., vol. xxiv, pp. 79–92, 1899.
Describes epeiroganic movements causing glaciation, the subsequent deformation of the region, and the character and distribution of the glacial deposits. Includes a bibliography of the subject.

665 —— [Review of "Eighteenth Annual Report of the United States Geological Survey".]
Am. Geol., vol. xxiv, pp. 122–125, 1899.

666 —— [Review of "Iowa Geological Survey, vol. ix".]
Am. Geol., vol. xxiv, pp. 182–184, 1899.

667 —— [Review of "Nineteenth Annual Report of the United States Geological Survey" and "Geological Survey of New Jersey, Annual Report for the year 1898."]
Am. Geol., vol. xxiv, pp. 251–253, 1899.

668 —— [Reviews of "Some Glacial wash-plains of southern New England," by J. B. Woodworth, and "The mechanical composition of wind deposits," by J. A. Udden.]
Am. Geol., vol. xxiv, pp. 381–382, 1899.

V.

669 **Van Hise** (C. R.). Introduction. [The Crystal Falls iron-bearing district of Michigan.]
U. S. Geol. Surv., Mon. XXXVI, pp. xvii–xxxvi; 19th Ann. Rept., Pt. III, pp. 9–18, 1899.
Describes the general character, occurrence, structure, and correlation of the Upper and Lower Huronian series in this region.

670 **Van Hise** (C. R.). The naming of rocks.
Jour. of Geol., vol. vii, pp. 686–699, 1899.
Discusses criteria and proposes a plan for naming rocks.

671 **Vaughan** (T. Wayland). Geologic notes on the Wichita Mountains, Oklahoma, and the Arbuckle Hills, Indian Territory.
Am. Geol., vol. xxiv, pp. 41–55, 1899.
Describes the physiographic features of the region, the character and occurrence of Silurian and Carboniferous strata and igneous rocks.

672 —— Some Cretaceous and Eocene corals from Jamaica.
Harvard Coll., Mus. Comp. Zool., Bull., vol. xxxiv, Appendix, pp. 227–250, 1899.
Reviews the literature on the corals from this region, and describes material collected by R. T. Hill.

673 **Veatch** (Arthur C.). The Shreveport area [Louisiana].
La. Exp. Stat., Part V, pp. 149–208, pls. xiv–xix, 1899.
Describes the physiography of the region and the occurrence of Tertiary deposits.

674 —— The five islands [Louisiana].
La. Exp. Stat., Part V, pp. 209–262, pls. xx–xxxi, 1899.
Describes the topographic and geologic features of the region and the occurrence of salt.

675 —— **Harris** (G. D.) and. General geology [of Louisiana].
See Harris (G. D.) and Veatch (A. C.). No. 283.

676 —— —— Historical review [of geological literature of Louisiana].
See Harris (G. D.) and Veatch (A. C.). No. 282.

677 **Vermeule** (C. C.). Water supply from wells [New Jersey].
N. J. Geol. Surv., Rept. for 1898, pp. 145–182, figs. 11–20, 1899.
Describes conditions which produce flowing wells and the progress of inflow through material about a well.

678 **Vogdes** (A. W.). Biographical sketch of Issachar Cozzens, jr.
Am. Geol., vol. xxiv, pp. 327–328, pl. xv, 1899.
Gives a sketch of his life.

W.

679 **Wagner** (George). On Tetracaulodon (Tetrabelodon) shepardii Cope.
Kan. Univ. Quart., vol. viii, pp. 99–103, pls. xxiv–xxv, 1899.
Describes material from the Loup Fork beds of Kansas and reviews literature of the subject.

680 **Walcott** (Charles Doolittle). Report of the Director of the United States Geological Survey for the fiscal year ending June 30, 1899.
U. S. Geol. Surv., 20th Ann. Rept., Pt. I., 551 pp., 2 pls., 1899.
Gives a general review of the work undertaken by the Survey during the year 1898–99.

681 **Walcott** (Charles Doolittle). Pre-Cambrian fossiliferous formations.

Geol. Soc. Am., Bull., vol. x, pp. 199–244, pls. xxii–xxviii, 1899. Reviews: Am. Jour. Sci., 4th ser., vol. viii, pp. 78–79; Science, new ser., vol. ix, p. 143 (½ p.), 1899.

Describes the character and occurrence of pre-Cambrian strata and the fossils collected.

682 —— Cambrian fossils [Yellowstone National Park].

U. S. Geol. Surv., Mon. XXXII, Pt. II, pp. 440–478, pls. lx–lxv. 1899.

Gives a summary of the faunas and descriptions of the Cambrian fossils collected.

683 —— Cambrian Brachiopoda, Obolus, and Lingulella, with description of new species.

U. S. Nat. Mus., Proc., vol. xxi, pp. 385–420, pls. xxvi–xxviii, 1899. Published in 1898.

684 —— Fossil Medusæ.

Abstracts: Am. Geol., vol. xxii, pp. 57–61; Jour. of Geol., vol. vii, p. 99, 1899.

See Bibliography and Index for 1898. No. 844.

685 **Walker** (T. L.). Crystal symmetry of the mica group.

Am. Jour. Sci., 4th ser., vol. vii, pp. 199–204, figs. 1–6, 1899.

Describes methods of study of crystal symmetry and discusses evidence of some of the micas belonging to the triclinic system.

686 —— Causes of variation in the composition of igneous rocks.

Review: Am. Geol., vol. xxiii, pp. 327-328 (½ p.), 1899.

687 **Ward** (H. L.). New Kansas meteorite.

Am. Jour. Sci., 4th ser., vol. vii, p. 233, 1 fig., 1899.

Briefly describes the material.

688 —— Notice of a new meteorite from Murphy, Cherokee County, North Carolina.

Am. Jour. Sci., 4th ser., vol. viii, pp. 225–226, pl. iv, 1899.

Describes occurrence and character of the material.

689 —— Notice of an aerolite that recently fell at Allegan, Michigan.

Am. Jour. Sci., 4th ser., vol. viii, pp. 412–414, 1899.

Describes occurrence and character of the material.

690 **Ward** (Lester F.). The Cretaceous formation of the Black Hills as indicated by the fossil plants (with the collaboration of W. P. Jenney, W. M. Fontaine, and F. H. Knowlton).

U. S. Geol. Surv., 19th Ann. Rept., Pt. II, pp. 521–946, pls. liii–clxxii, figs. 117–122, 1899. Review: Jour. of Geol., vol. vii, pp. 814–815, 1899.

Reviews literature on the Black Hills, gives a historical sketch of the discovery of the fossils and numerous sections of the strata and descriptions of the fossils.

691 **Ward** (Lester F.). Descriptions of the species of Cycadeoidea or fossil Cycadean trunks thus far determined from the Lower Cretaceous rim of the Black Hills.

U. S. Nat. Mus., Proc., xxi, pp. 195–229, 1899. Published in 1898.

692 **Warren** (C. H.), **Penfield** (S. L.) and. Some new minerals from the zinc mines at Franklin, N. J., and note concerning the chemical composition of ganomalite.

See Penfield (S. L.) and Warren (C. H.), No. 522.

693 —— —— Chemical composition of parisite and a new occurrence of it in Ravalli Co., Montana.

See Penfield (S. L.) and Warren (C. H.), No. 521.

694 **Washington** (Henry S.). The petrographical province of Essex County, Massachusetts, II.

Jour. of Geol., vol. vii, pp. 53–64, 1899.

Describes the megascopic, microscopic, and chemical characters of essexite, diorite, and gabbro.

695 —— The petrographical province of Essex County, Massachusetts, III.

Jour. of Geol., vol. vii, pp. 105–121, 1899.

Describes the petrographic and chemical character of aplite, quartz-syenite-porphyry, paisanite, sölvsbergite, tinguaite, and dike rocks.

696 —— The petrographical province of Essex County, Massachusetts, IV.

Jour. of Geol., vol. vii, pp. 284–294, 1899.

Describes petrographic and chemical character of camptonite, diabase, rhyolite, and keratophyr.

697 —— Petrographical province of Essex County, Massachusetts, V. (General discussion and conclusion.)

Jour. of Geol., vol. vii, pp. 463–482, pl. vi, 1899. Review: Am. Geol., vol. xxiv, pp. 255–257, 1899.

Gives a general summary of previous papers.

698 **Watson** (Thomas L.). Some notes on the lakes and valleys of the Upper Nugsuak Peninsula, North Greenland.

Jour. of Geol., vol. vii, pp. 655–666, 3 figs., 1899.

Describes physiographic features of the region and the occurrence and origin of the lake.

699 —— Some further notes on the weathering of diabase in the vicinity of Chatham, Virginia.

Am. Geol., vol. xxiv, pp. 355–369, 1899.

Discusses the evidences of the cause of the considerable loss of alumina in the change from fresh to decomposed diabase. Includes many chemical analyses.

700 **Watts** (W. L.). Notes on the oil-yielding formations of California.

Min. and Sci. Press, vol. lxxix, pp. 144–146 (12 figs.), pp. 172–173 (3 figs.), 1899. Describes character and occurrence.

701 **Weed** (Walter Harvey). Fort Benton folio, Montana.

U. S. Geol. Surv., Geol. Atlas of U. S., folio No. 55, 1899.

Describes the general geologic features and the occurrence and character of the Archean, Cambrian, Silurian, Devonian, Carboniferous, Juratrias, Cretaceous, Pleistocene, and igneous rocks. Discusses the geologic history of the region, and describes the occurrence of coal, gold, and silver. Includes topographic maps and columnar sections.

702 —— Little Belt Mountains folio, Montana.

U. S. Geol. Surv., Geol. Atlas of U. S., folio No. 56, 1899.

Describes the physiography, the occurrence, and character of the Archean, Algonkian, Cambrian, Silurian, Devonian, Carboniferous, Juratrias, Cretaceous, metamorphic, and igneous rocks, the general geologic relations and history of the region, and the occurrence of coal, silver, and sapphires. Includes topographic and geologic maps and columnar sections.

703 —— Geology of the southern end of the Snowy Range [Yellowstone National Park].

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Jour. of Geol., vol. vii, pp. 737–750, 1899.

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712 —— [Review of "Fossil Medusæ," by C. D. Walcott.]

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713 —— [Review of "Fifteenth Annual Report of the State Geologist [New York] for the year 1895, vol. i."]

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716 —— [Review of "The Paleozoic reticulate sponges constituting the family Dictyospongidæ," by James Hall and J. M. Clarke.]

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